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THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 52 SEPTEMBER, 1944 No. 3

THE ROENTGENOGRAPHIC DIAGNOSIS OF THE SMALL CENTRAL PROTRUDED INTERVERTEBRAL DISC

INCLUDING A DISCUSSION OF THE USE OF PANTOPAQUE AS A MYELOGRAPHIC MEDIUM

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INTRODUCTION

THE characteristic lateral defect in the myelogram produced by the usual disc protrusion has become familiar through the studies of Hampton and Robinson,[5] Bradford and Spurling,[1] and others. There is a small group of patients with disc protrusions in which this defect is not found during the course of the usual myelographic examination.

It is the purpose of this report to describe the myelographic appearance in 5 such cases in which a small central protruded intervertebral disc was found at operation.

Eck,[3] in describing the location of disc protrusions, says: "Less commonly it (the protrusion) may occur centrally with symptoms of partial cord compression in the more severe cases, but with only moderate soreness in the milder cases. At some time following central rupture, however, the protruding material may migrate laterally with ensuing typical nerve root symptoms." Bradford and Spurling[1] state: "A midline defect is unusual," and "The diagnosis of midline herniations is largely a roentgenographic problem because in such cases the symptoms are chiefly limited to the back without the characteristic radicular findings." Horwitz[6] expressed doubt as to "whether such a minimal lesion (a small central disc protrusion) would be productive of sufficient symptoms and signs to warrant exploration."

TECHNIQUE

The practice of the Neurosurgical Section at this hospital has been to request a myelographic examination in every case of suspected protruded intervertebral disc where the lesion has been incident to Army service.

The patient is placed in the lateral recumbent position with his head towards the head end of the roentgenographic-roentgenoscopic tilt table. Care is taken, as with the usual lumbar puncture in this position, to see that both shoulders are in the same vertical plane, and that the head, trunk and knees are well flexed.

After preparing the skin, the subcutaneous tissues down to the interspinous ligaments are injected with novocain solution at the site of puncture, usually the third, but occasionally the second, lumbar interspace. On obtaining a free flow of spinal

fluid, the contents of one ampule of pantopaque, 3 cc., is injected firmly and steadily. If the injection is done hesitantly and intermittently, the opaque fluid may break up into globules.

The stilet of the lumbar puncture needle is then replaced, and the patient cautioned to turn over slowly so that he will lie flat on his abdomen. He is then moved so that the soles of his feet are placed firmly against the foot rest of the tilt table.

This procedure usually leaves a homogeneous column of pantopaque at the level of the third lumbar vertebra. The table is then tilted so that the opaque fluid descends the spinal canal slowly; the advancing margin of the column is watched for slight deformities until the third lumbar interspace is bridged. If slight persisting deformities are observed, "spot" roentgenograms are made to show various degrees of development of the deformity. The table is tilted still further, and the fourth and fifth (lumbosacral) discs and the cul-de-sac are investigated roentgenoscopically and "spot" roentgenograms are made. The column is then allowed to ascend the lumbar spine as the table is tilted towards the horizontal and the advancing edge is observed carefully for slight deformities. The last three interspaces are then roentgenoscoped in each oblique and "spot" roentgenograms made.

The patient is turned again into the prone position, and by tilting the table, the opaque column is maneuvered beneath the needle. The oil is aspirated and a roentgenoscopic check made to be certain that as much of it was removed as was practicable. Using the over-the-table tube, a 10×12 inch film, centering on the lumbar puncture needle, is exposed. This film is used to orient the small films properly. The needle is withdrawn, and the examination is at an end.

Since most of the cases of protruded intervertebral disc have occurred at the fourth and fifth interspaces, only the last three interspaces are examined. This obviates extensive roentgenoscopic radiation of the patient, and the exposure of an excessive number of films. Where the clinical examination indicates, the upper segments of the spine are examined.

If a nerve sleeve fails to fill, the column is moved back and forth by tilting the table to "inject" the oil into the sleeve. The movement of the oil produced by coughing is also used as an aid.

The roentgenograms are made with the roentgenoscopic tube using a "spot" film device. The anteroposterior and moderate oblique views are the only ones made. The lateral projection, made with the roentgen-ray beam either horizontal or vertical has not been as helpful as the oblique views. In addition, satisfactory roentgenograms are obtained much more readily in the oblique position.

CASE REPORTS

The 5 cases of small midline protruded intervertebral discs were detected by myelography using pantopaque. All were proved at operation. In each instance the patient obtained relief of symptoms following removal of the protruded disc. The cases formed part of a group of over 150 cases examined by myelography, 86 of which were operated upon.

CASE 1. F. A. C., aged thirty-one. This soldier was admitted to a station hospital complaining of progressively severe backache following Judo instruction. His back was strapped, but he could not get out of bed the next day. On examination, the patient listed to the left; straight-leg raising was limited to 30 degrees on the right and to 45 degrees on the left. There was localized tenderness over the left erector spinae. Clinical examination showed the lumbosacral joint to be normal.

Examination at this hospital showed a slight scoliosis of the spine, convexity to the left. There was about 10 degrees' limitation of motion, and a positive Lasègue sign, on the right side. The right ankle jerk was diminished.

The myelographic examination showed no abnormalities until the inferior margin of the opaque column was brought to the upper edge of the lumbosacral disc (Fig. 1*b*). At this point the edge of the pantopaque showed a defect, concave downwards, on the right side. As the

opaque material was slowly advanced across the interspace, it was seen to envelop progressively a rounded defect on this side (Fig. 1*c*). Yet when the interspace was completely bridged the column was apparently normal (Fig. 1*a*). On close inspection a small transsized defect was partially outlined on the left side (Fig. 2*b*). In partial outline, the defect appeared larger and more prominent than when the oil column completely bridged the intervertebral space.

At operation two weeks later, a small disc

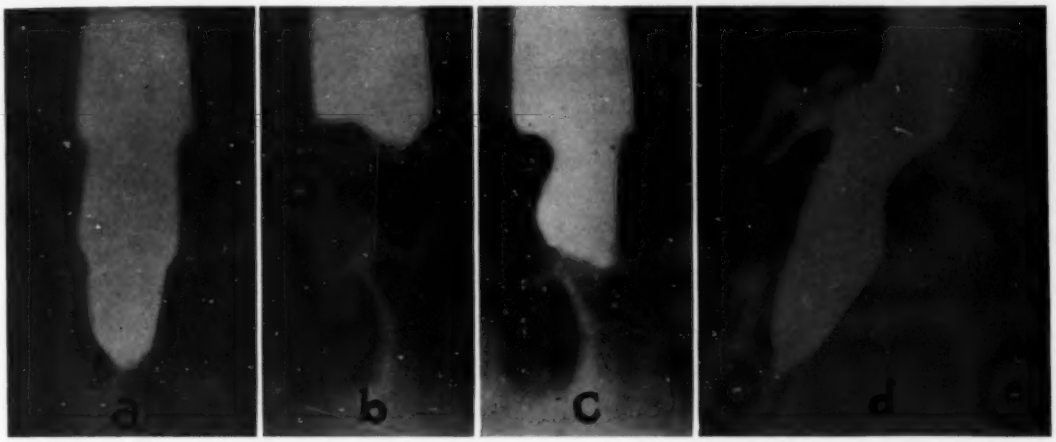

Fig. 1. Case 1. *a*, the pantopaque column, lying fully across the lumbosacral disc, shows no defect or alteration of the nerve sleeves. *b*, when the oil is allowed to enter the level of the interspace gradually, a defect is produced, concave downward, in the right side of the advancing edge. *c*, with the oil advanced still farther, a defect in the right side is more clearly outlined. Referring to (*a*), an area of slight translucency may be detected at this site. *d*, in the oblique view, there is a characteristic defect in the anterior aspect of the pantopaque.

lucent area can be made out at this site and there is a slight asymmetry in the levels of the nerve exits. The oblique myelogram (Fig. 1*d*) showed a defect on the anterior aspect which also suggested the diagnosis of a small protruded intervertebral disc.

At operation a small central protruded disc was found and removed.

Case II. J. D. J., aged twenty-eight. This soldier had a moderate back injury in 1932, without residual difficulty. He began to experience an ache in his lower back four weeks after admission. It was gradual in onset and of low intensity. It later became constant, and soon radiated to the left thigh and leg. The backache was aggravated by coughing and sitting.

On physical examination, leg stretching was painful on the left. The left knee jerk was decreased, and the ankle jerk absent.

Myelographic examination showed a slight indentation in the left side of the pantopaque column at the level of the lumbrosacral disc (Fig. 2*a*). On allowing the edge of the opaque fluid to enter this area gradually, a moderate-protrusion, almost in the midline, was seen to push a flattened nerve root posteriorly and laterally. The disc substance was removed.

Case III. W. W. T. This soldier began to have pain in the small of the back in April, 1943, following a ride in a vehicle. The pain had become gradually worse, but still remained localized to the same area. The backache was aggravated by coughing, sneezing or bending.

The back was tender to pressure over the third and fourth lumbar vertebrae. Flexion of the back was limited. He experienced pain when he returned to the upright position after bending. The reflexes were active and equal. The hyperextension test was normal, as was the Lasègue sign. There were no sensory disturbances. All laboratory studies on the blood and urine were normal.

Myelographic examination showed a pronounced defect in the right side of the pantopaque column when the edge of the oil was allowed gradually to enter the level of the fourth intervertebral space (Fig. 3, *b* and *c*); not only was this seen when the column was brought

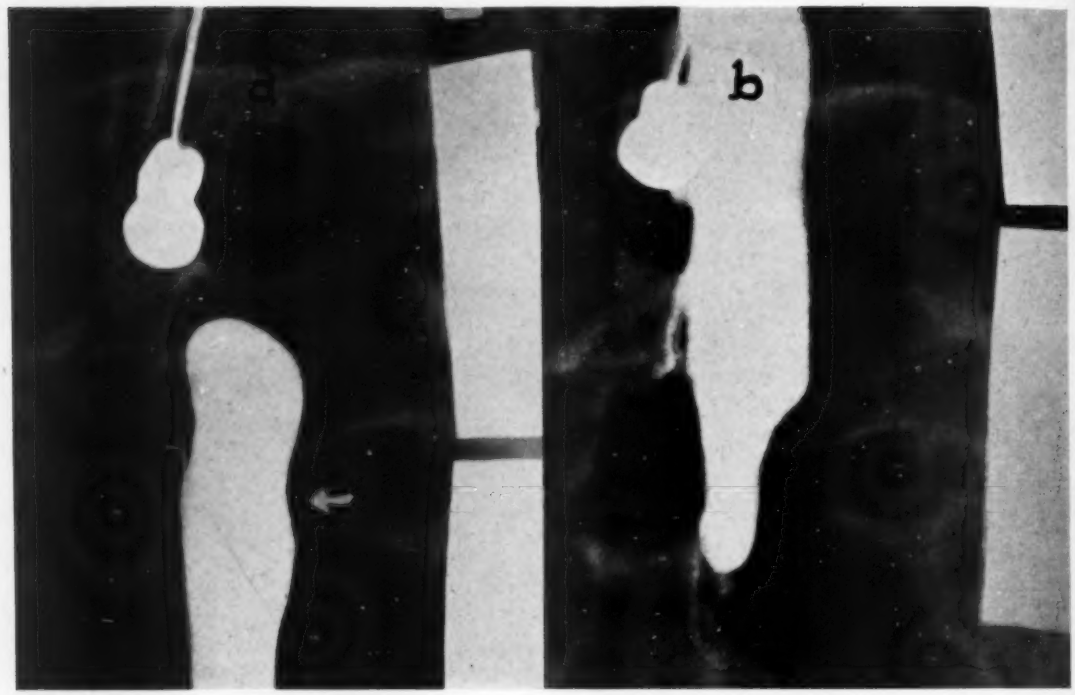

FIG. 2. Case II. *a*, there is slight flattening along the left side (arrow) which was persistent on several of the myelograms. *b*, when the edge of the oil was allowed to enter this region, there was evidence of a definite defect. The evidence noted in (*a*), without that observed in (*b*) was insufficient for a diagnosis of a disc protrusion.

downwards, but the lower margin of the defect was outlined when the oil was allowed to ascend from the cul-de-sac (Fig. 3*d*). When the oil bridged the entire interspace no defect could be seen (Fig. 3*a*), but there was a slight elevation of the left nerve root as compared with the right. The oblique projections also showed the defect in the opaque column (Fig. 3*e*).

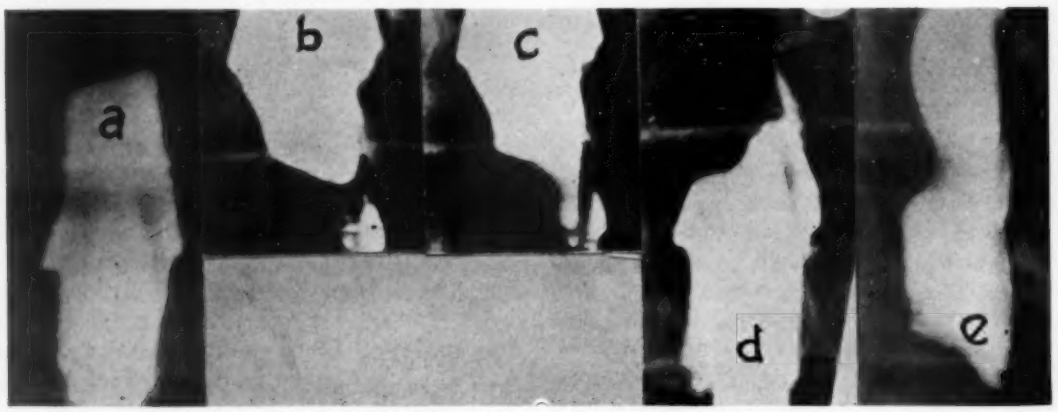

FIG. 3. Case III. The myelograms are arranged so that the affected disc (fourth) lies at the same level in all. *a*, the full column of oil shows no defect or alteration of the nerve sleeves. *b*, no defect is seen as the oil enters the upper level of the interspace. *c*, as the oil slides just a little farther, it outlines the left side of a defect. *d*, the oil was allowed to descend to the cul-de-sac and then brought upwards; the lower edge of the defect is outlined. *e*, the oblique view demonstrates a characteristic defect in the anterior aspect of the oil column.

At operation, a centrally situated disc protrusion was discovered and the disc substance removed.

CASE IV. F. M. N., aged thirty. In January, 1943, this patient noted low backache while doing desk work. About a month later he had a severe attack of backache, without radiating pain, which lasted three or four days. About two months after the onset of the original pain, he had another severe attack, this time with severe pain in his left leg. He improved slowly with bed rest. A month later he was hospitalized for persistent back pain, with radiation to his left leg, which was aggravated by coughing and sneezing.

There was deep tenderness at the level of the fourth lumbar vertebra on the left side. Hyperextension of the leg was limited by pain. Straight leg raising was possible to 85 degrees on the right and 50 degrees on the left, with a positive Lasègue sign on this side. There was a zone of hyperesthesia to pin prick on the lateral aspect of the left lower leg and the external malleolus. The left ankle jerk was slightly decreased and easily exhausted

On myelographic examination, a small concavity was noted in the lower edge of the pantopaque column at the lumbosacral interspace (Fig. 4*b*). When the entire interspace was bridged by the opaque oil, no defect could be seen (Fig. 4*a*). These findings were not discovered during the roentgenoscopic examination. A small amount of pantopaque remained in the dural sac, so the patient was re-examined. Even though the amount of oil was small, it appeared to surround the upper pole of a small disc protrusion (Fig. 4, *c* and *d*). Another examination with the full amount (3 cc.) of the oil definitely outlined the small protrusion which had been suggested at the time of the first myelographic examination (Fig. 4, *e* and *f*). There was evidence also of a small protrusion of the fourth lumbar disc.

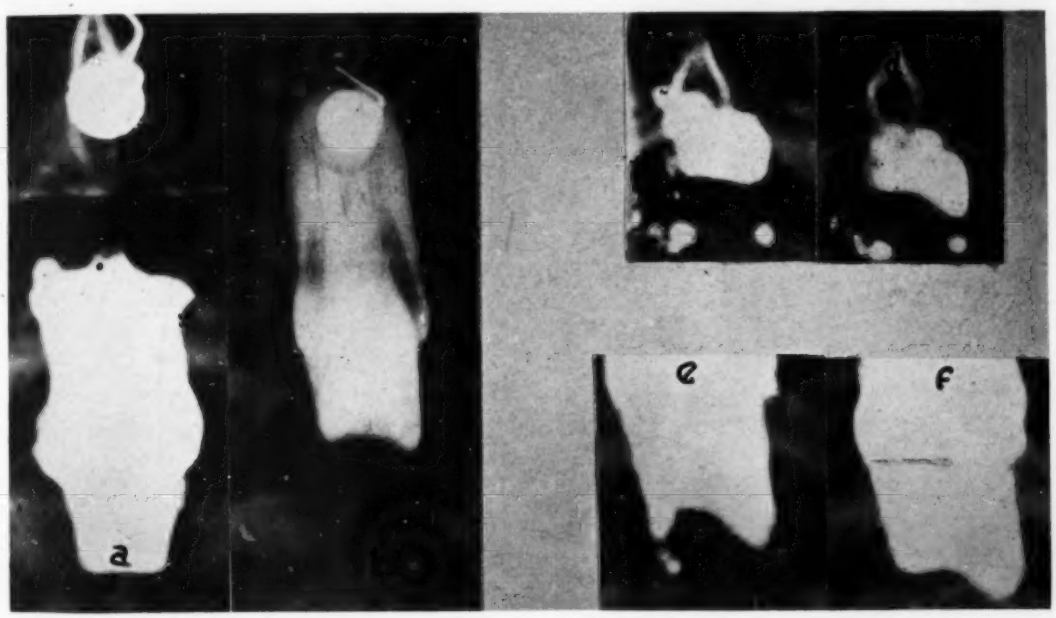

FIG. 4. Case IV. *a*, the appearance of the pantopaque column is normal when the interspace is fully covered. *b*, a defect, concave downwards, at the inferior margin appeared to outline the upper edge of a disc protrusion. This had not been noted during the roentgenoscopic examination. *c* and *d*, the patient was recalled, and although the amount of oil remaining was very small, it could be made to outline the upper margin of a small protruded disc. *e* and *f*, in order to verify these findings, the myelographic examination was repeated at a later date. A defect is again demonstrated. Oblique views confirmed the diagnosis of a disc protrusion.

At operation, a small but definite central protrusion was seen at the lumbosacral disc, accompanied by localized scarring of the posterior longitudinal ligament.

CASE V. J. A. K., aged twenty-four. While on maneuvers in October, 1941, a vehicle in which this soldier was a passenger overturned. He

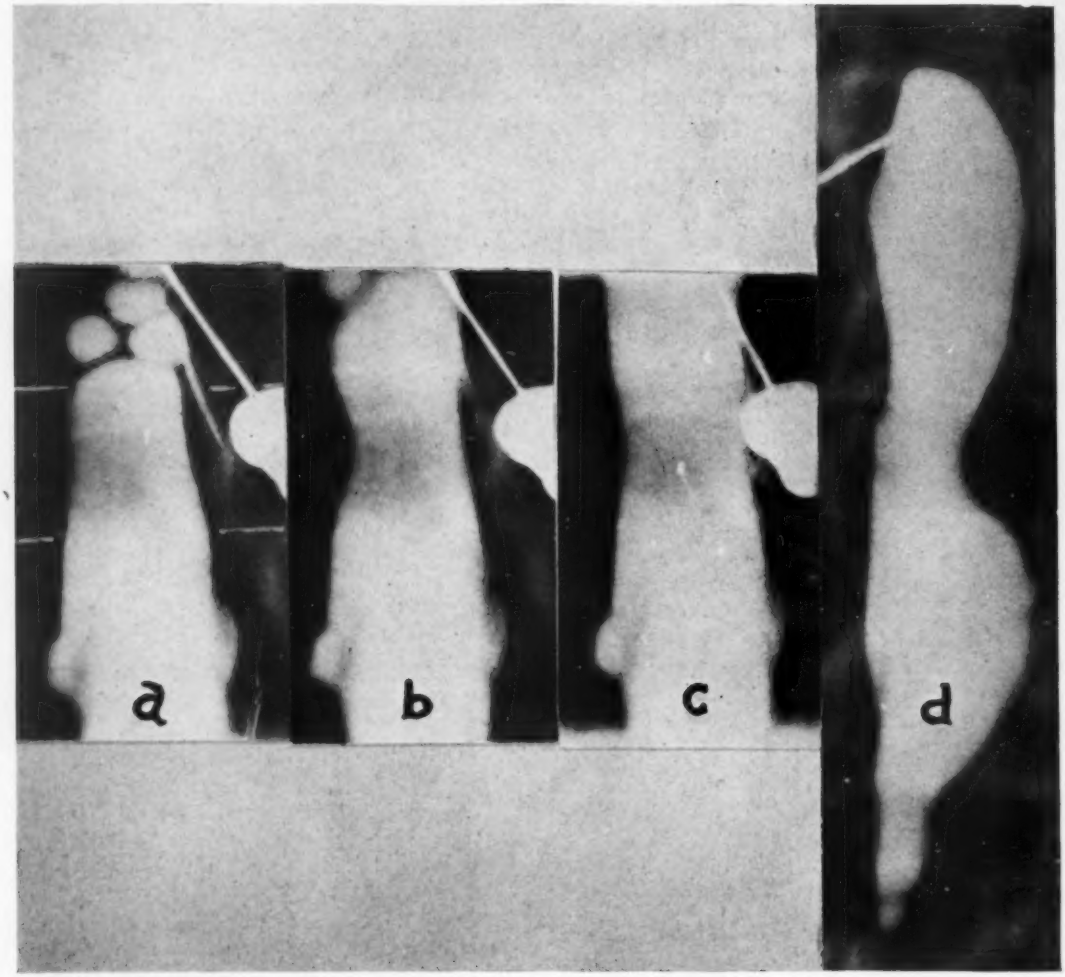

FIG. 5. Case v. The margins of the interspace in (*a*) are retouched. The interspace is at the same level in all of the illustrations. *a*, *b* and *c* show the persistent translucency at the intervertebral interspace with a suggestion of a constriction in this region. *d*, the oblique view indicates the diagnosis of a protruded disc.

suffered an acute low back strain which incapacitated him for three days. Since then he has had constant low back pain, which was worse on arising in the morning. He had suffered acute attacks of left sciatic pain which lasted from a few minutes to several days. Coughing often aggravated the pain.

There was deep tenderness at the left side of the third lumbar vertebra. Flexion was one-half of normal; all other movements were normal. Straight leg raising was impaired, and a positive Lasègue sign was present on the left side. Naffziger's sign was also positive. The knee and ankle joints were normal. There were no sensory changes.

The myelographic examination showed no defect in the margins of the pantopaque column, but did show a persistent localized translucency in the midline at the level of the third lumbar interspace (Fig. 5, *a*, *b* and *c*). The oblique views showed an indentation at the anterior aspect of the opaque column (Fig. 5*d*).

At operation, on exposure of the left side of the third lumbar interspace the nerve sheath was seen to be pushed posteriorly and slightly laterally; it was adherent to a large protrusion of the third lumbar intervertebral disc; the disc was removed.

DISCUSSION

In this group of cases—all central disc protrusions—4 were detected by careful

observation of the slowly advancing edge of the pantopaque column to outline a small herniation or rupture of the disc substance. In 4 of the 5 cases the outline of the oil column was practically normal when it completely bridged the level of the protrusion aside from asymmetry of the nerve exits. In the other case (Case II) there was a slight deformity which in itself was insufficient to warrant a positive diagnosis. In 1 of the cases (Case V) only a translucent area in the frontal projection suggested the presence of the small disc protrusion.

The defect in each case was small, yet in each case it was productive of pain and, in each case, relief from the pain was obtained after removal of the protruding disc.

The discovery of these lesions was undoubtedly facilitated by the use of pantopaque. This new opaque myelographic medium was introduced within the past two years. Clinical use at this hospital in over 150 myelographic examinations in the period of slightly over a year has supplied convincing proof of its many advantageous properties.

Contrast myelography, first described by Dandy[2] in 1919 has since come into considerable use, particularly in the detection and localization of protruded intervertebral discs. Air was the first contrast substance suggested and used. It is still staunchly advocated by a few, although the consensus that its accuracy and definition are well below that of lipiodol can hardly be questioned. This latter substance, introduced by Forestier and Sicard,[4] came into extensive use. Thorotrast, despite its many desirable features, is not used because of its radioactivity and the inconvenience encountered in its complete removal.

Of late there has been a great decrease in the use of lipiodol in spite of the excellent use which had been made of it in the past. This may be due in part to occasional clinical reactions, the frequent difficulty encountered in its removal and the aggravation of symptoms which frequently occur when it is incompletely removed.

Pantopaque is a very freely flowing, oily substance which has given the distinct impression that it has less tendency to break up into globules than does lipiodol. It maintains itself in a homogeneous column, which fills the nerve sleeves very readily.

Pantopaque casts an excellent shadow on the roentgenogram but it is not so opaque that it obscures fine gradations of density. It is not radioactive. It is a stable solution which is not miscible with spinal fluid. Chemically it is a mixture of ethyl esters of isomeric iodophenylundecylic acids. The material has proved to be nontoxic both on experimental and clinical use. In most of the patients all but a few droplets has been removed. Occasionally, because the needle was somewhat off center, it was found impossible to remove any or all of it.

In all but one of the patients in whom the opaque material has been allowed to remain, no ill effects of any kind were suffered.[9] There were no symptoms other than those for which the patients were admitted to the hospital. This includes 2 of the patients examined for cervical protruded discs in whom a small amount of pantopaque entered the cranial cavity. One case in which the material was inadvertently injected epidurally also showed no symptoms or reactions to the drug. The only case in which symptoms occurred was a recent patient whose upper dorsal spine was examined; about 1 cc. of the material entered the cranial cavity in the region of the pontine cistern. This patient became nauseated and vomited. It is conceivable that the reaction was not specific for pantopaque but could have been produced by any fluid which had been displaced in the same way.

Pantopaque is said to be absorbed slowly (about 1 cc. a year).[8] We have had no follow-up studies longer than six months after the original examination and therefore cannot attest to its absorbability. Since the material is so innocuous and unproductive of reactions, the question of absorbability seems unimportant, either clinically or medicolegally. Most of the pantopaque in the few patients examined up to six months

after myelography had remained freely movable; the rest usually extended along the lumbar or pelvic nerves. It may be deduced from this that a reactive arachnoiditis has not resulted.

The great variety of conditions with low back pain, with or without sciatic radiation as a manifestation, makes a differential diagnosis difficult from a clinical point of view. While it is true that a well developed case of protruded intervertebral disc may be detected in the majority of the cases (about 60 per cent)[7] by clinical examination alone, it seems unreasonable to resort to exploratory procedures in the other cases when a harmless and easily performed method of investigation is available.

The accuracy of the procedure using pantopaque can logically be expected to be greater than that of the clinical investigation alone. With very few exceptions, in experienced hands, this method will permit discovery of a disc lesion. It lends itself admirably to the detection of the early small protruded disc, which has been demonstrated to our satisfaction as the causative lesion in a small group of cases of troublesome low backache.

The myelographic examination will also demonstrate the level of the protrusion, whether it is single or multiple, and, frequently, whether the defect is due to a disc lesion or a tumor.

SUMMARY AND CONCLUSIONS

The characteristic lateral defect in the opaque oil column which is indicative of a protruded intervertebral disc is absent in a small but significant group of cases when careful roentgenoscopic observation of the moving opaque column is employed. Frequently the patients in this group complain of low back pain which does not radiate early in the course of the disease. Often there is serious doubt from the clinical examination concerning the diagnosis of a protruded disc unless myelographic evidence of a small central disc protrusion is elicited.

In the performance of myelography in cases which are suspected of suffering from disc protrusion it is important to allow the edge of the oil column to advance slowly and gradually so that the margins of a small protrusion will be outlined before the bulk of the oil obscures it. Five cases of small central disc protrusions were discovered in this way.

The myelographic examination is greatly facilitated by the use of pantopaque, a new medium developed especially for this purpose. It is of low viscosity, unproductive of reactions, tends to remain homogeneous, and is not excessively opaque.

Appreciation is expressed to Dr. M. L. Sussman for his helpful suggestions in the preparation of this paper.

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IODIZED OIL MYELOGRAPHY OF THE CERVICAL SPINE*

OBSERVATIONS ON THE NORMAL AND ON FIVE PATIENTS WITH RUPTURED INTERVERTEBRAL DISCS OF THE LOWER CERVICAL SPINE

By BERNARD S. EPSTEIN, M.D., *and* LEO M. DAVIDOFF, M.D.
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ALTHOUGH widespread attention has been directed to the diagnosis of herniations of the nucleus pulposus of the lower lumbar spine, similar lesions in the lower cervical region have also been described. Love and Walsh[5] and Dandy[2] reported that ruptured discs occur in the lower lumbar region in approximately 96 per cent of cases. Mixter and Ayer,[6] however, encountered 8 patients out of 34 in whom the protrusion of the nucleus pulposus occurred in the lower cervical region. Hawk[4] collected 16 such cases and reported 1 additional patient. Semmes and Murphey[8] ventured the opinion that the incidence of this lesion is not infrequent in their report on the syndrome of unilateral rupture of the sixth cervical intervetebral disc.

The roentgenologic approach to the diagnosis of herniation of the nucleus pulposus of the lower cervical spine, particularly iodized oil myelography, merits further attention. Stookey[9] ascribes some significance to narrowing of the intervertebral spaces in this diagnosis when accompanied by definite neurologic signs suggestive of one of the syndromes of spinal cord compression or root pain. However, he deemed it inadvisable to use iodized oil because it might enter the basal cisterns and possibly the cranial cavity over the cerebral cortex. Semmes and Murphey concluded that in their patients the diagnosis could be made more accurately by clinical means than by the use of contrast media. Neither reported myelographic observations, although the latter mentioned that one of their patients had had iodized oil studies elsewhere with negative results.

We have had the opportunity of studying 5 patients with rupture of the nucleus pulposus of the lower cervical spine. There were 76 patients in our entire series of ruptured discs, the remaining 71 occurring in the lower lumbar region. Oil myelography as well as routine roentgenographic studies of the affected region were made on each of 38 patients, and operative confirmation was obtained in all.

Myelography was performed after the instillation of 1.5 to 2 cc. of pantopaque or lipiodol into the lumbar subarachnoid space. The patient was then placed face down on a motor driven tilt table equipped with a device for spot film roentgenography. With the patient held securely in place, the table was tilted and the movement of the oil column followed roentgenoscopically. It was necessary to invert the patient to an angle of from 70 to 85 degrees for the oil to enter the upper thoracic and lower cervical regions. The movement of the table was under the control of the observer, so that if the oil passed too rapidly into the lower cervical canal the table could be returned promptly to the horizontal position. In this way it was possible to prevent the entrance of the opaque medium into the cranial cavity.

OBSERVATIONS ON NORMALS

It was considered essential to familiarize ourselves with normal myelographic findings in the cervical spinal canal. This was done on 8 patients in whom myelography was indicated for other reasons and who had no symptoms or signs referable to the cervical region.

* From the Neurosurgical Service of Dr. L. M. Davidoff and the Radiologic Service of Dr. M. G. Wasch, The Jewish Hospital of Brooklyn.

While the opaque medium flowed through the lumbar spine it passed as a solid column. Approaching the thoracic spine, particularly the cephalad third, there was a definite tendency for the oil to break up into various sized droplets. When this occurred it was necessary to repeat the examination after returning the patient to the erect position to permit the oil to collect in the lumbar sac. A satisfactory examination could not be made unless the oil was kept in as complete a column as possible.

Assuming that the opaque medium passed satisfactorily as a solid column into the cervical canal, the observer had to be alert to detect the changes which occurred at the level of the lower three cervical vertebrae. There is a normal hesitation at the region of the distal portion of the cervical canal which is very transitory. Following this pause the column usually passed to either side of the canal, outlining the axillary pouches as tiny triangular shadows with their apices directed laterally following the configuration of the cervical nerves as they pass through the intervertebral foramina (see Fig. 1, 2 and 3). It was difficult to fill the entire cervical canal, but it could be accomplished by tilting the patient up and down to collect the oil in the lower cervical canal.

These observations assume added importance because the myelographic changes associated with herniation of the nucleus pulposus of the lower cervical spine reported here are principally changes in the rate of flow and appearance of the oil column.

OBSERVATIONS ON PATIENTS WITH HERNIATION OF THE NUCLEUS PULPOSUS OF THE LOWER CERVICAL SPINE

Four of the patients with herniations of the nucleus pulposus of the lower cervical spine presented a roentgenologic picture of partial obstruction to the passage of iodized oil in the affected region which was fairly uniform, could be repeated on the same patient with identical results and has not to our knowledge been described up to the present time. The fifth patient had a complete cerebrospinal fluid block.

The following observations were common to 4 patients. As the oil column approached the lower cervical region, which occurred when the patient was almost inverted and usually after several attempts, it halted briefly but definitely longer than normal at the level of the lesion, changing its appearance to a large globule with a flat or convex base directed cephalad. After a few seconds a thin trickle of oil appeared either to one or both sides of the lesion. As the obstruction was passed the oil fell in various sized droplets with increased speed toward the cisterna magna.

Although the delay in the passage of the iodized oil at the site of the lesion was brief a few serial spot roentgenograms could be made of the process. Adequate information was usually obtained without oil entering the cranial cavity. In 1 patient some lipiodol entered the cisterna magna but emerged after the patient had been placed in a semi-erect position for a few hours.

On the spot roentgenograms the oil was first seen gathered in a large globule with a flat or convex base simulating a cap-like configuration. Successive roentgenograms showed a thin trickle of oil passing to one or both sides of the spinal canal for 2 to 5 cm. Beneath this and between the lateral ribbons of oil, droplets were scattered. Viewing the roentgenograms in the position in which they had been taken, i.e., head downwards, a characteristic appearance like that of an inverted "U" or "L" with broad base and thread-like arms with oil droplets beneath and between the arms was seen. In contrast with the normal appearance, the oil did not enter the axillary pouches.

Our observations indicated that ruptured intervertebral discs protruding into the lower cervical canal might result either in no obstruction or partial or complete block. In those patients with little or no cerebrospinal fluid block the myelograms resembled those described by Walker, Jessico and Marcovich[10] for intramedullary cord tumors. However, several significant

differences were noted. Intramedullary cord tumors act on iodized oil within the spinal canal by compressing the oil between the tumor mass and the periphery. This results in a cap-like defect proximal to which lateral streaks may extend for several segments on one or both sides of the canal, depending on the length and diameter of the tumor. Small triangular protrusions may be seen between the pedicles due to lipiodol in the axillary pouches, as can be noted on the illustrations in the paper by these authors.[10] In the presence of a herniated disc of the lower cervical spine the cap-like defect is transitory and unless watched for carefully may be overlooked. The lateral streaks are shorter, and the opaque oil does not gather in the axillary pouches. The presence of oil droplets between the lateral streaks is significant because it indicates the absence of a mass in that region. The myelographic characteristics of herniation of the intervertebral disc in the lower cervical region are transitory, while an intramedullary spinal cord tumor produces a more or less fixed appearance.

Complete intraspinal block occurred in 1 patient out of the 5 reported here. When present it cannot be distinguished from that due to extramedullary tumors. The latter, in contrast with herniated discs, are often associated with changes in the adjacent osseous and soft tissue structures which may be of diagnostic importance.[3]

Other uncommon conditions such as a cyst of the spinal cord,[1] or syringomyelia,[7] or a perineural fibroblastoma* may simulate an intramedullary tumor and therefore might be confused with a herniated disc in the lower cervical region.

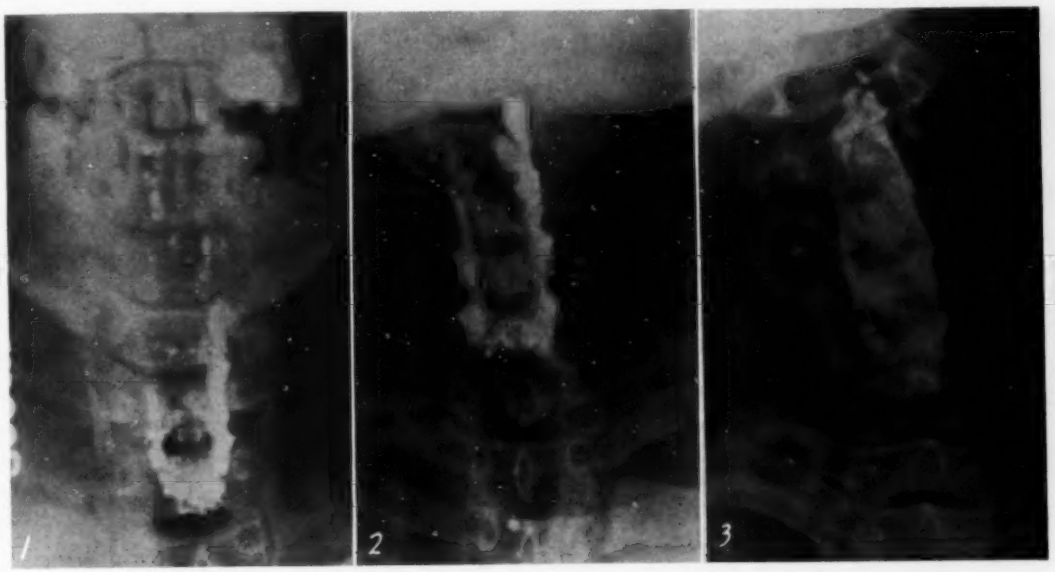

Fig. 1. Spot roentgenogram made with the patient inverted during iodized oil myelography of the cervical spine in a normal individual. Most of the opaque oil has passed to either side of the spinal canal outlining the axillary pouches. Oil droplets are present between the lateral ribbons and are gathered at the interspace between the sixth and seventh cervical vertebrae.

Fig. 2. Spot roentgenogram made during iodized oil myelography of a normal cervical region. The axillary pouches are well filled, and the iodized oil at the time this roentgenogram was made had assumed a rapidly transient "U" appearance.

Fig. 3. Spot roentgenogram showing the entire cervical canal filled with iodized oil. The axillary pouches are well portrayed.

* Unreported verified cases operated upon at the Jewish Hospital.

REPORT OF CASES

CASE 1. J. L., male, aged forty-nine, first noted difficulty in using his left leg while walking and weakness of his left hand three months before admission. He had been aware of a tingling "pins and needles" sensation in his left hand prior to this. One month before admission tingling appeared in his right hand.

Physical examination revealed partial ptosis of his left upper eyelid. There was weakness of his left upper extremity with ataxia and adiadokokinesis. A left Hoffmann sign was elicited. The abdominal reflexes were diminished on the left side. The knee jerks were hyperactive bilaterally. There was bilateral ankle clonus and patellar clonus on the left side. A positive Babinski sign was present on the right. Position sense of the right big toe was impaired, and vibratory sense of both lower extremities was diminished. Pain sensation was decreased on the right side from the level of the sixth thoracic segment down, but the saddle area was spared. There was spasticity of both lower limbs, more marked on the left side.

The cerebrospinal fluid was crystal clear, and normal hydrodynamic responses were obtained. The protein content was 47 mg. per 100 cc.

Anteroposterior and lateral roentgenograms of the cervical spine revealed slight arthritic changes in the lower cervical vertebrae with normal interspaces. Myelography after the instillation of 2 cc. of pantopaque in the lumbar sac showed free passage of the opaque medium through the lumbar and thoracic canal. At the level of the interspace between the fifth and sixth cervical vertebrae there was a temporary obstruction, and the column changed its appearance momentarily to a large globule with a flat base. Soon thereafter the opaque oil passed to either side of the cervical canal. Roentgenograms made during this time revealed a "U"-shaped configuration with droplets of oil beneath the base of the "U."

At operation a definite herniated disc was found between the fifth and sixth cervical vertebrae compressing the spinal cord anteriorly. The herniation protruded on both sides. The pia-arachnoid vessels were markedly injected

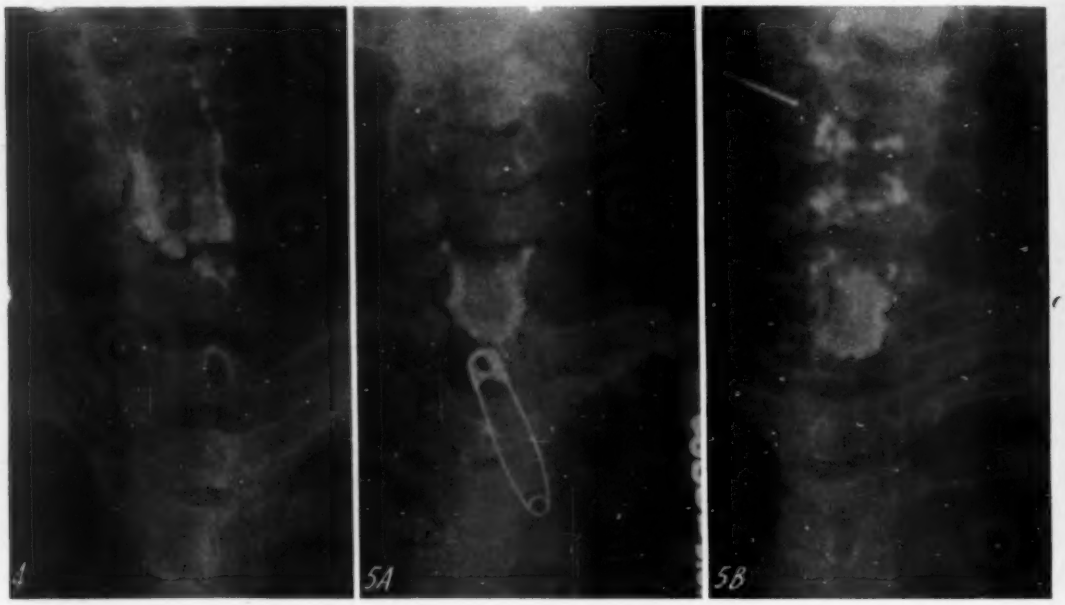

FIG. 4. Case 1. Spot roentgenogram with the patient inverted. The lipiodol assumes a "U" appearance which is more lasting than normal, with droplets of oil beneath and between the lateral streaks.

FIG. 5. Case 11. *A*, spot roentgenogram taken just as the oil reached the site of the lesion. The pantopaque column presents a cap-like deformity which might be confused either with an intramedullary or an extramedullary tumor. *B*, spot roentgenogram a few seconds later. The lateral streaks of iodized oil are broken, and oil droplets are seen between them.

and there were numerous adhesions between the arachnoid and dura. The adhesions were broken and the laminectomy was affected to act as a decompression. Only slight subjective improvement followed the operation.

Case II. B. G., female, aged forty-five, suddenly noted weakness and numbness in both legs about six weeks before admission. Her legs felt "heavy" and she had to drag them in an effort to walk. There was no pain at this time, and her symptoms were attributed to her diabetic condition. Two weeks before admission she had severe low back pain on arising in the morning. The pain was sharp and did not radiate until two days later when it extended to both flanks, abdomen and the upper gluteal regions. There was no history of lifting or straining.

Physical examination revealed the deep reflexes to be equal and active. Normal plantar responses were obtained bilaterally. The abdominal reflexes were absent. No motor weakness or atrophy was found. There were moderate subjective changes consisting of hyperalgesia below the level of the sixth thoracic segment anteriorly. Pain and temperature sensations were unimpaired.

The cerebrospinal fluid was crystal clear. There was a partial block, the initial pressure being 140 mm. and the final pressure after the removal of 10 cc. of fluid being zero. The cerebrospinal fluid proteins were 74 mg. per 100 cc.

Anteroposterior and lateral roentgenograms of the cervical spine showed normal bodies and interspaces. Oil myelography after the injection of 2 cc. of pantopaque into the caudal sac revealed a partial obstruction at the level of the interspace between the sixth and seventh cervical vertebrae. The oil then trickled to either side of the spinal canal and several droplets fell cephalad. Spot roentgenograms confirmed these observations which were reported as suggestive of a herniated disc at this site.

At operation a laminectomy of the fifth, sixth and seventh cervical vertebrae and the first thoracic vertebra was performed. On the left side of the cord between the sixth and seventh cervical vertebrae there was a posterior bulge of the anterior surface of the canal, the appearance of which was quite suggestive of a posterior herniation of the intervertebral disc. Removal was deemed inadvisable. There was no definite improvement after operation.

Case III. E. G., male, aged sixty-one, first noted spasmodic clonic contractions of his left leg one year before admission. These occurred several times a week, principally at night. There was no pain associated with them, nor was there any history of trauma or strain. About six months later pain appeared in his right shoulder, followed by tremors of the right upper extremity, weakness and poor coordination of the movements of his right hand. The pain in his right shoulder was increased by coughing. He also complained of choking sensations in the sternal region, but cardiologic examination including electrocardiographic and roentgenologic studies showed no evidence of heart disease.

Physical examination revealed his left pupil to be smaller than the right, with enophthalmos of the left eye and slight ptosis of the left lid. The cranial nerves were intact. There was diminution of pain sensation on the right side from the level of the third cervical vertebra downward, with the saddle area spared. The deep reflexes were equal and active. Slight ataxia was noted in the heel to knee test bilaterally. A positive Babinski sign was elicited on the left side. Vibratory sense was unimpaired.

The cerebrospinal fluid was crystal clear, and normal hydrodynamic responses were elicited. The cerebrospinal fluid protein content was 70 mg. per 100 cc.

Anteroposterior and right lateral roentgenograms of the cervical spine revealed marked hypertrophic osteoarthritis, particularly of the lower cervical segments, with narrowing of the lower intervertebral spaces.

Myelography after the instillation of 2 cc. of lipiodol revealed a temporary obstruction at the level of the sixth cervical vertebra. After a brief delay a thin stream of oil passed to the left side of the canal resulting in an "L"-shaped shadow which was considered suggestive of a herniation of the nucleus pulposus.

At operation a ruptured disc was found on the left side of the sixth cervical intervertebral space. The dura over this region was opened and dense adhesions of the pia-arachnoid to the entire surface of the dura were found. A decompression of the lower cervical canal was affected by means of laminectomy of the fourth, fifth and sixth cervical vertebrae. The mass protruding into the spinal canal was not attacked. After operation the patient suffered a cerebral thrombosis and died. Autopsy permission was denied.

CASE IV. A. B., male, aged forty-seven, felt a sharp pain in his right shoulder ten months before admission. This occurred while he was lifting a hundred pound weight onto a truck. The next day the pain radiated to the back of his neck, and his head was tilted towards the right side. This lasted two days, and attempts to bring his head back to the midline were quite painful. A few days later pain appeared in his left shoulder. He was bedridden for the next six weeks, and the pain gradually subsided. He then returned to work, and was symptom free for two weeks. The pain recurred after a prolonged period of driving. A spinal tap done soon thereafter was reported as normal. Four months before admission his gait became abnormal in that his toes hit the ground first while he was walking, and he had difficulty in maintaining his balance. About this time he began to feel numbness and coldness in his left great toe. Recently his finger tips became numb, and pins and needles sensations appeared. He also had difficulty in performing finer hand movements because of a progressive intention tremor in his right hand. The symptoms had become more marked up to his admission to the hospital.

On physical examination there was a slight weakness of the grip of his left hand, and a definite intention tremor of his right hand. A slight left foot drop was present, and there was poor coordination in the performance of the heel to knee test bilaterally. The abdominal reflexes were diminished. Positive Hoffmann and Babinski signs were elicited on both sides, the right more active than the left. There was bilateral exhaustible ankle clonus.

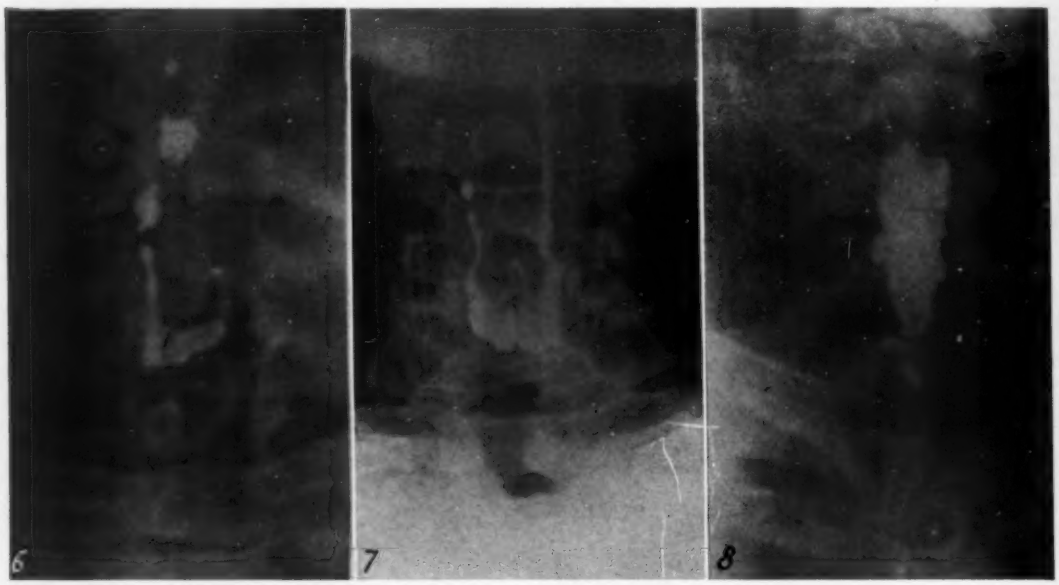

FIG. 6. Case III. Spot roentgenogram showing an "L" configuration of the iodized oil column.
FIG. 7. Case IV. Spot roentgenogram showing "U" configuration of the lipiodol column. The oil does not gather in the axillary pouches of the lower cervical nerve roots.
FIG. 8. Case V. Spot roentgenogram revealing a complete cerebrospinal fluid block.

The cerebrospinal fluid was clear, and normal manometric responses were obtained. The cerebrospinal fluid protein content was increased to 72 mg. per 100 cc.

Anteroposterior and lateral roentgenograms of the cervical spine showed slight osteoarthritic changes in the lower cervical vertebrae. Iodized oil myelography revealed a temporary obstruction at the fifth cervical interspace. A few seconds after the oil column reached this site lateral streaks of opaque oil could be seen passing to either side of the spinal canal resulting in a "U" configuration. The spot roentgenograms confirmed these observations.

At operation laminectomy of the fifth, sixth and part of the seventh cervical vertebrae was performed. A herniation of the nucleus pulposus between the fifth and sixth cervical vertebrae

was seen coming from the left side pushing the cord posteriorly and towards the right side. The anterior nerve roots were displaced posteriorly and inferiorly.

After operation there was some improvement so far as his sensory disturbances were concerned, but the changes in gait persisted.

Case v. J. B., male, aged fifty-seven, suddenly felt a peculiar prickling sensation in both palms about five months before admission to the hospital. Six weeks later numbness appeared in both hands. Weakness and cramps of both hands followed. There was no recent history of trauma or unusual strain. His right lower limb had been amputated three years ago because of gangrene following trauma.

Physical examination revealed weakness of both upper limbs, more marked on the right. There was beginning spasticity of his fingers. The deep reflexes in both upper extremities and the remainder of the left leg were increased. A bilateral Hoffmann sign was present, and the abdominal reflexes were diminished bilaterally. There was loss of sensation to pain and temperature in a zone corresponding to the fourth cervical to first thoracic segments. Touch was preserved in this area. Position sense was markedly impaired in the fingers of both hands, and occasional errors were noted in his toes. Vibratory sense was diminished below the level of both clavicles. Stereognostic sense was impaired in both hands. There were suggestive Oppenheim and Chaddock signs in his left foot.

The cerebrospinal fluid was clear. A partial block was present, the initial pressure being 120 mm., and the pressure after the removal of 10 cc. of fluid being 62 mm. The total proteins were increased to 134 mg. per 100 cc.

Anteroposterior and lateral roentgenograms of the cervical spine revealed advanced hypertrophic osteoarthritis involving the lowermost vertebrae. Lipiodol myelography after the injection of 2 cc. of lipiodol revealed complete obstruction at the interspace between the fifth and sixth cervical vertebrae. At operation a laminectomy of the fifth and sixth cervical vertebrae was performed. Extradural exploration revealed a large herniation of the intervertebral disc protruding toward the right side. The overlying nerve roots were stretched taut. The disc could not be removed. After operation the patient noted considerable improvement in the power of his left upper extremity, but the right upper limb improved only slightly.

COMMENT

Four patients were men between the ages of forty-seven and sixty-one, and the fifth was a woman aged forty-five. One (Case iv) had a history of strain which was of clinical significance. One (Case iii) had substernal pain which was readily distinguished from angina pectoris. Three of the herniations of the nucleus pulposus occurred between the sixth and seventh cervical vertebrae and two between the fifth and sixth.

The distribution of pain was bizarre. In contradistinction to ruptured intervertebral discs of the lower lumbar spine, where low back pain is a predominant symptom, patients with similar lesions in the lower cervical spine in this series had little pain referable to that area. Only 1 patient (Case iv) had pain in the base of the neck. Another had pain in the lower lumbar region (Case ii) and 3 had no back pain at all. Weakness, paresthesias and pain in both upper limbs were observed in 1 patient (Case v). Right arm symptoms were noted in 2 patients (Cases iii and iv) and 1 had sensory disturbances in the left arm (Case i). Lower extremity pain, weakness and paresthesias occurred in 4 patients, and was absent in the one who had most of his symptoms referable to his upper extremities. The latter was the patient who had a complete cerebrospinal fluid block (Case v).

The tendon reflexes were normal in 4 patients, and were increased in the one with the complete cerebrospinal fluid block. A positive right Babinski sign was elicited in 2 patients, a positive left Babinski sign was present in 1, and a doubtful Babinski sign was observed in a fourth patient. One patient (Case ii) had a normal flexor response. Position sense was normal in 3 patients, and impaired in the remaining 2 patients (Cases i and v). Vibratory sense was diminished in 2 patients (Cases ii and v). Three showed changes in gait of a shuffling nature, and a foot drop was seen in one. Pain and temperature sensation was diminished in 4 patients, but the levels were bizarre. Touch sensation was impaired in 2,

both of whom had pain and temperature changes.

The symptomatology in all 5 patients reported here was referable to the dorsal funiculi, the pyramidal tracts and the lateral and ventral spinothalamic tracts. The levels of the neurologic disturbances as determined clinically were at considerable variance with what might have been expected from the location of the herniated discs. These patients fell into the syndrome of compression of the spinal cord described by Stookey[9] with bilateral or unilateral ventral pressure, with the effects of the pressure referable to both the upper and lower limbs. Root pain was also noted, but was not a predominating symptom.

The cerebrospinal fluid dynamics were normal in 3 patients, and 2 had partial blocks. Elevated protein content was found in all but one (Case 1).

Routine anteroposterior and lateral roentgenograms of the cervical spine revealed advanced hypertrophic osteoarthritis with narrowing of the lower intervertebral spaces in 3 patients. We do not ascribe any definite significance to this finding, inasmuch as it is frequent in patients of the same age who have no complaints referable either to the spine or the central nervous system.

SUMMARY

Routine roentgenographic and the clinical findings may be confusing in the diagnosis of herniation of the nucleus pulposus of the lower cervical spine.

The normal opaque oil myelographic findings in this region are described, and observations made on five patients who had verified herniated discs of the lower cervical spine are reported. Myelography of the cervical canal is a procedure which can provide valuable information, and which merits further study and careful evaluation. With care it is possible to perform the examination without iodized oil entering the cranial cavity. In instances in which some of the opaque medium did enter the cisterna magna no difficulty was encountered in returning it to the spinal canal after placing the patient in the upright position.

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A ROENTGEN ANALYSIS OF THE MOTION OF THE LOWER LUMBAR VERTEBRAE IN NORMAL INDIVIDUALS AND IN PATIENTS WITH LOW BACK PAIN

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ALTHOUGH recent years have added considerably to our knowledge of low back pain, there are still many patients in whom the most painstaking clinical and roentgen examination fails to disclose a causative factor. The reason for this is probably to be found in the fact that there are many intervertebral soft tissue structures which are invisible to the roentgen ray and inaccessible to clinical examination.

In search for more accurate roentgen diagnosis some authors have recommended that the spine be studied not only in its anatomical detail but also in its motion. So far, however, no one has attempted to analyze the vertebral movements in normal individuals and in patients suffering from low back pain.

Before attempting this analysis, one should be familiar with the structures involved and with the stresses generated by motion. From an anatomical standpoint, the movement of the vertebrae is dependent on a normal muscular action and on the integrity of the intervertebral discs and of the posterior articular facets. The type of movement of the various spinal segments is determined by the direction of the planes of the posterior articulations. For instance, the plane of the posterior articulations of the cervical vertebrae is more nearly horizontal than in other segments of the spine and this accounts for the greater mobility of this segment. In the dorsal spine, the facets are almost vertical so that this segment can rotate well, but does not flex freely from side to side. In the lumbar segment, the posterior articulations allow extension, flexion, and lateral flexion while only a slight amount of rotation is permitted by the articulations of the fourth and fifth lumbar vertebrae.

The posterior articulations of the spine, strange as it may seem, are not shaped so that they will fit one another in the extreme degrees of motion. In extreme flexion and extreme extension of two vertebrae of the lumbar type, the posterior articular facets will touch each other at an angle and over a limited surface. This fact creates strains upon certain regions of the articular cartilages (Fig. 1).

The intervertebral discs form a very versatile type of joint and would allow motion in all directions were it not for the guiding action of the posterior articulations. This guiding action accounts for the fact that the flexion of the spine is accompanied by a slight forward displacement of the vertebrae while the extension is accompanied by a slight backward motion.

The motion of the vertebrae creates a series of stresses in the intervertebral discs. With the spine in flexion the discs become wedge shaped and this causes a tendency of the nuclear substance to slide backward toward the open side of the wedge (Fig. 1). The reverse holds true in extension. This tendency of the nuclear substance to slide back and forth is restrained by the annulus fibrosus and by the many fibrils which bind the soft nuclear substance to the vertebral bodies above and below. The solid bond of the nuclear substance to the vertebral bodies is easily seen upon sectioning an intervertebral disc. The nuclear substance is soft and jelly like, but cannot be easily displaced.

A factor of great importance in the function of the intervertebral discs is their internal pressure. This pressure is the result

of the load and of the force of the elastic and connective fibers which compose the structure of the annulus and which constrict and limit the incompressible nuclear substance. An intervertebral disc may be thus likened to a tire in which an incompressible semifluid material has been forced into a tough elastic casing. This intranuclear pressure is obviously essential to the proper function of a disc and varies with the load to which the disc is subjected. For instance, the pressure within the cervical discs is bound to be much lower than that within the discs of the lumbar region. If we assume that the weight of the trunk above the fifth lumbar disc is 100 pounds and the surface of the disc is 1 square inch, then this disc may have to support a pressure of 200 or 300 pounds during the lifting of some weight, and as much as 400 or 500 pounds during a fall.

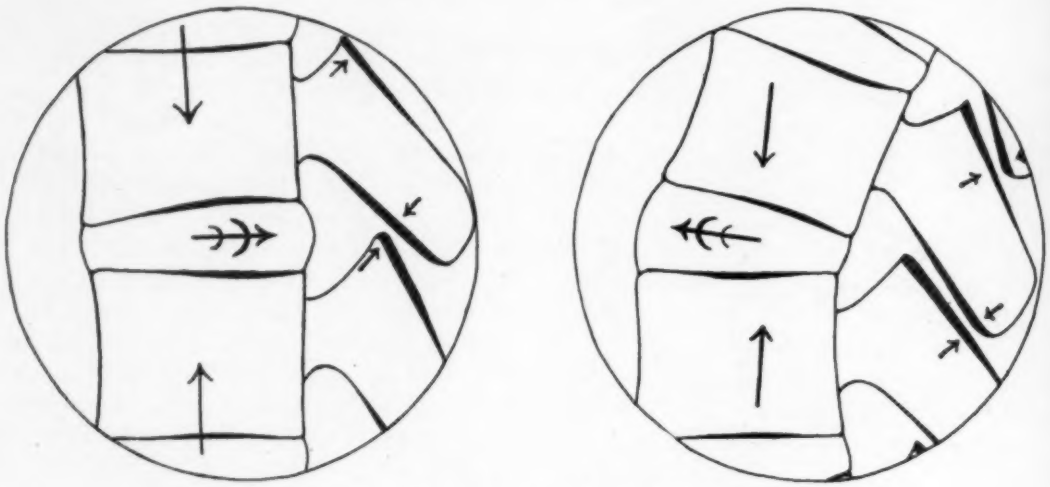

FIG. 1. Stresses upon the intervertebral discs and the posterior articular facets created by extreme flexion and extreme extension.

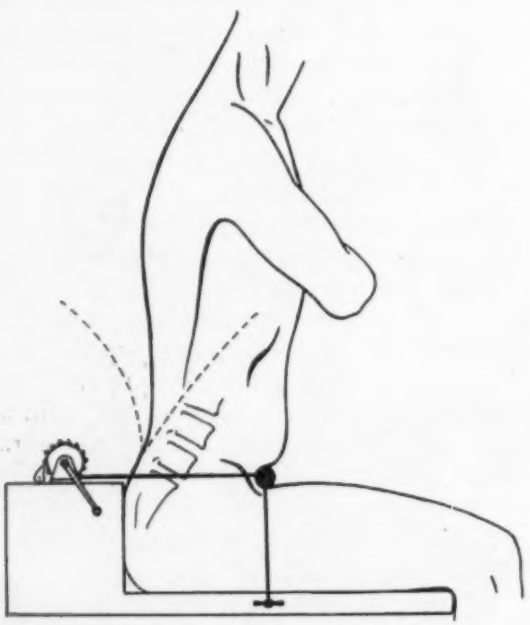

FIG. 2. Method of immobilizing the pelvis for the motion study of the lumbosacral spine.

From this rather sketchy review, it appears that the normal movements of the spine are connected with several factors and that these include muscular pull, load upon the discs, intranuclear pressure, and the condition of the articular facets. These factors vary with the various regions of the vertebral column and are altered by certain pathological conditions.

A little over a year ago it occurred to me that it should be possible to give a roentgenological demonstration of the pattern of motion of the various vertebral segments. By taking three roentgenograms of the lumbosacral spine in the lateral position, one with the spine at rest, one with

the spine in flexion, and one with the spine in extension, I was able to see that, after superimposing the sacrum in the three roentgenograms, the shadows of the lower border of the fifth lumbar crossed each other in a definite manner. These roentgenograms were taken with the patient recumbent. Later on, a technique was developed which allowed the study of vertebral motion while the spine supported the weight of the body. This technique requires the use of a special seat, the essential features of which are shown in Figure 2. The patient sits in this device with the trunk erect so that the spine supports its normal load. A back rest extends as high as the upper limit of the sacrum. The pelvis is immobilized by the backward pull of two straps attached to a horizontal bar resting against the anterosuperior iliac spines. The horizontal bar is held down by two other straps secured to the bottom of the seat. The roentgen-ray beam is horizontal, and a small cone minimizes secondary radiation. The film is held by a rack on the side opposite the roentgen tube. Three films are exposed, one with the trunk erect, one with the trunk in maximum flexion, and one with the trunk in maximum extension, taking care that all the exposures are made with the spine in a strictly vertical sagittal plane. These three roentgenograms usually show the sacrum and the last two or three lumbar vertebrae in true profile so that the shadow of each of these structures is superimposable on the shadow of the same structure in all roentgenograms.

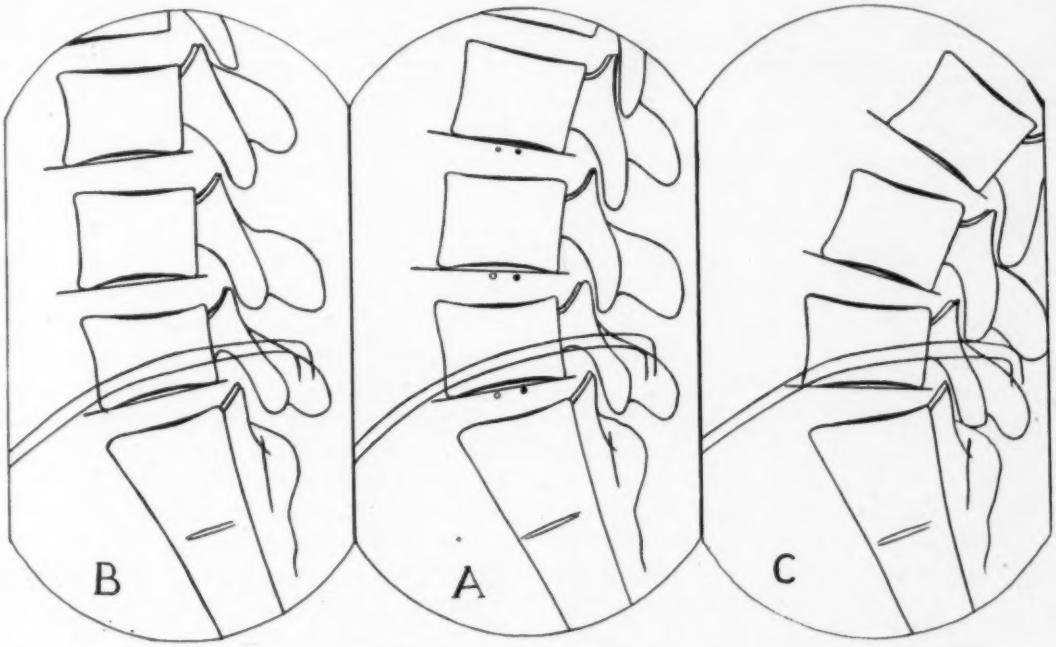

Fig. 3. Method of marking the three roentgenograms for the study of vertebral motion.

If this is not the case, referring points cannot be found and the study of vertebral motion should not be attempted. Only after having obtained a good set of roentgenograms can one proceed with their comparison and study.

The roentgenogram obtained with the trunk erect (Fig. 3, *A*) is placed on an illuminator, and, with a sharp pointed pencil, straight lines are drawn tangential to the lower contours of all the vertebrae to be studied. The roentgenogram obtained with the trunk in flexion (Fig. 3, *B*) is then placed over roentgenogram *A*, and the contours of each vertebra in the two roent-

genograms are superimposed as accurately as possible; then lines corresponding to the lines already drawn on roentgenogram *A* are drawn on roentgenogram *B*. This process is then repeated by superimposing *A* and the roentgenogram taken in extension (Fig. 3, *C*). These roentgenograms

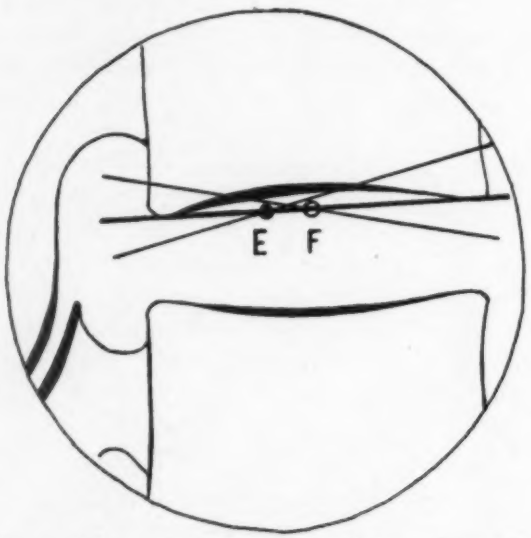

FIG. 4. Normal position of the fulcra of motion.

are now ready for study. With the roentgenogram *A* uppermost, one superimposes the sacrum in *A* on *B*. Then one marks on roentgenogram *A*, with a small circle, the point where the lines delineating the lower edge of the fifth lumbar vertebra in the two roentgenograms cross each other. This circle represents the fulcrum of flexion of the fifth lumbar vertebra. The next step is to superimpose the sacrum in roentgenograms *A* and *C*, and, to mark on *A* with a dot the crossing of the lines drawn at the lower edge of the fifth lumbar. This dot represents the fulcrum of extension of the fifth disc.

This process is repeated for the fourth and for the third lumbar discs.

So far no routine attempt has been made to study the motion of the vertebrae above the third lumbar because such a study would require a different and more complicated device. An attempt was made to study the lateral flexion of the lumbar spine, but was not pursued because the anteroposterior or posteroanterior views will give a good representation of only one disc at a time.

It is obvious that the terms "fulcrum of flexion" and "fulcrum of extension," although descriptive, are not very accurate. We are dealing with the flat surface of the vertebral body as it slides over the turgid nuclear substance and the marks on roentgenogram *A* actually represent the extreme points at which this surface is tangential to the ovoid shape of the nucleus. It should be understood that between the two extreme points there are many others which would be shown by roentgenograms taken in intermediate degrees of flexion and extension.

Twenty individuals between the ages of nineteen and thirty-five years, without any previous history of backache and without roentgen findings of bone lesions, were examined with the technique described above. The fulcra of flexion and extension of the third, fourth, and fifth lumbar discs were found to lie within very narrow limits at about the center of the nuclei (Fig. 4). The average distance between fulcra was 5 mm., with a minimum of 3 mm. and a maximum of 8 mm. The fulcrum of flexion was always anterior to the fulcrum of ex-

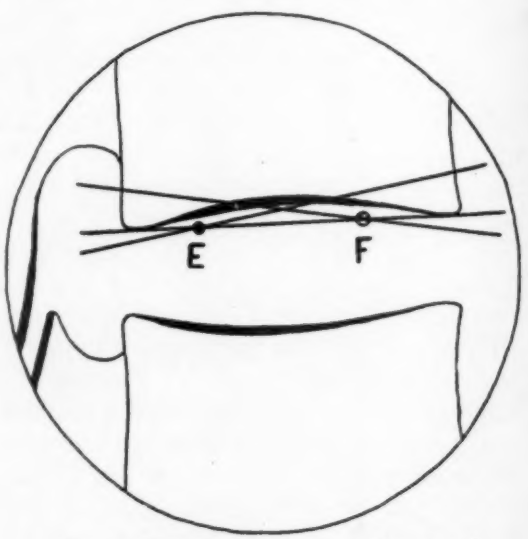

FIG. 5. Spread of the fulcra of motion.

tension. The vertebral bodies themselves showed a complex motion: in flexion they moved slightly forward and in extension there was a slight backward component.

The pattern of motion of the lumbar spine in normal cases is evidently due to the rolling of the flat surfaces of the vertebral bodies over the nuclei, while the vertebrae are being guided by the posterior articulations. This pattern is about what one would expect from the study of the anatomical structures involved.

Thirty-five patients complaining of low back pain were studied with the same technique and the motion of their lumbar spines compared with that found in the normal individuals.

Twenty of these patients showed normal motion; 15 showed deviations from normal.

Of the 20 patients who had back pain with normal motion, 16 had no demonstrable bone lesions. Of these 16 patients, 2 had clinical symptoms of posterior herniation of the nucleus pulposus. The lesions found in the remaining 4 patients are described in Table 1.

Of the 15 patients who had back pain and abnormal motion, 8 had no evidence of bone lesions. Four of these 8 patients had clinical symptoms of a posterior herniation of the nucleus. The bone lesions found in the remaining 7 patients are described in Table 1. Only one disc per patient was involved in 9 of the 15 patients showing abnormal motion. Six patients, however, showed abnormal motion at more than one level, so that in these 15 patients, abnormal motion was found a total of 21 times. The types of abnormal motion can be described as follows:

In 5 discs the fulcra were separated more than normally. This was due to a contemporaneous spread of both fulcra in 2 discs (Fig. 5), to a forward displacement of the fulcrum of flexion in 1 disc, and a backward displacement of the fulcrum in extension in 2 discs.

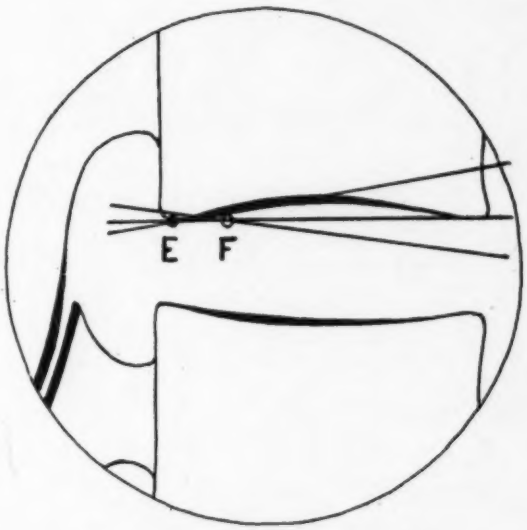

Fig. 6. Posterior displacement of the fulcra of motion.

In 2 cases the fulcra were at normal distances from each other but displaced backward close to the posterior edge of the disc (Fig. 6).

Table I

Number of cases with low back pain: 35

Normal motion: 20 cases (54%)		Abnormal motion: 15 cases (46%)	
Without bone lesions: 16 cases		Without bone lesions: 9 cases	
With bone lesions: 4 cases		With bone lesions: 7 cases	
Bone lesions found:		Bone lesions found:	
	Cases		Cases
Spondylolisthesis, grade 1:	1	Spondylolisthesis, grade 2:	2
Hypertrophic changes:	1	Hypertrophic changes:	1
Schmorl's nodes:	2	Osteochondritis juvenilis:	1
		Old compression fracture:	1
		Unilateral sacralization of the fifth lumbar:	2

In 4 discs there was a reversal of the normal position of the fulcra, with the fulcrum of flexion being placed posteriorly and fulcrum of extension anteriorly. Two of these also showed a marked increase in the distance between the fulcra (Fig. 7).

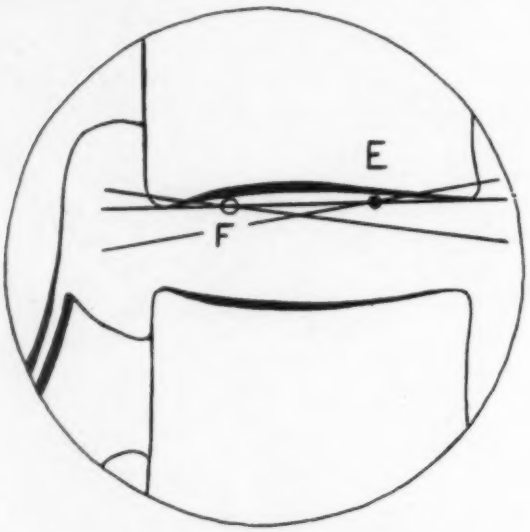

FIG. 7. Reversal in the position of the fulcra of motion.

In 2 discs the fulcrum of extension was displaced so far backward that it was found to be at the level of the posterior articulations (Fig. 8).

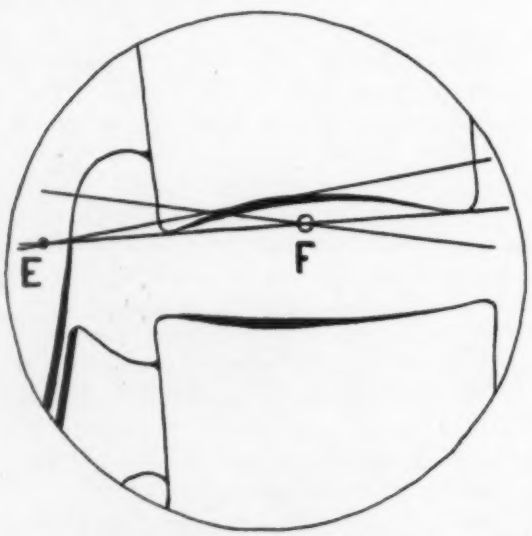

FIG. 8. Displacement of the fulcrum of extension to the level of the articular processes.

In 2 discs either the fulcrum of extension or that of flexion could be marked on roentgenogram *A*, but in the opposite movement, the vertebra above the disc moved up or down like a plunger so that the lines drawn at the lower edge of the body were parallel (Fig. 9).

In 2 disks there was such limitation of flexion that no fulcrum of flexion could be established.

In 2 discs there was no motion at all. Both of these discs were under partially sacralized fifth lumbar vertebrae.

The disc most frequently involved was the fourth lumbar disc.

Any attempt to explain abnormal vertebral motion must take into consideration

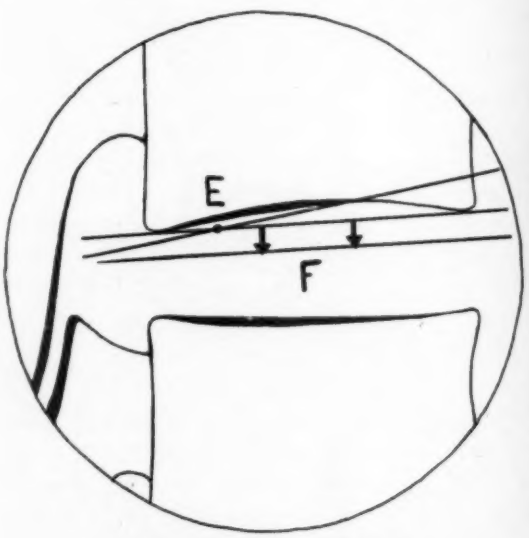

FIG. 9. Plunger type of flexion.

all the factors involved in the movements of the spine.

The first factor to be considered is that of muscular action. The only abnormality of muscular action noted was spasm. This was present in 4 of the 15 patients who showed abnormal motion, but in 2 of these 4 patients the muscle spasm disappeared following the administration of ½ grain of morphine half an hour before their examination. The 2 other patients still had some spasm at the time of the motion studies, but while one would expect muscle

spasm to affect the motion of all the lumbar vertebrae, in each of these patients only 1 disc was involved. It seems, therefore, that muscle spasm played no part in the production of abnormal motion.

The second factor to be considered is the effect of the bony lesions found in 7 of the 15 patients showing abnormal motion. Bone changes were certainly responsible for the lack of motion found in the 2 patients who had sacralization of the fifth lumbar vertebra, and for the abnormal motion found at the level of the lumbosacral disc of the 2 patients with spondylolisthesis. It must be noted, however, that in both patients with spondylolisthesis, there was abnormal motion also at higher levels (Fig. 10), and that this abnormal motion at higher levels cannot be explained by the lesion found at the lumbosacral junction. The effects of the bony lesions found in the remaining patients must also be critically evaluated. In the patient showing old osteochondritis, this condition affected the whole lumbar spine, but only the fourth disc showed abnormal motion. In the patient showing an old compression fracture, the abnormal motion was not at the disc adjacent to this fracture, but at a disc removed from it. It appears, therefore, that the abnormal motion in only 4 cases out of 21 can be attributed to the presence of bone lesions.

The third factor to be considered is the behavior of the posterior articulations of the spine. Recalling the stresses to which the articular facets are subjected during vertebral motion, it seems reasonable to assume that some damage to the sliding cartilages was responsible for the 2 instances in which there was posterior displacement of the fulcrum of extension to the level of the articular processes and, perhaps, for the 2 instances in which the motion was of a plunger type.

There remain 13 instances of abnormal motion in which an explanation must be sought in some changes involving the intervertebral discs.

In order to gain an understanding of how changes in the intervertebral discs can affect motion of the spine, one must recall that their pathological conditions include the following: first, the normal aging process in which the nuclear substance gradually loses some of its water content;

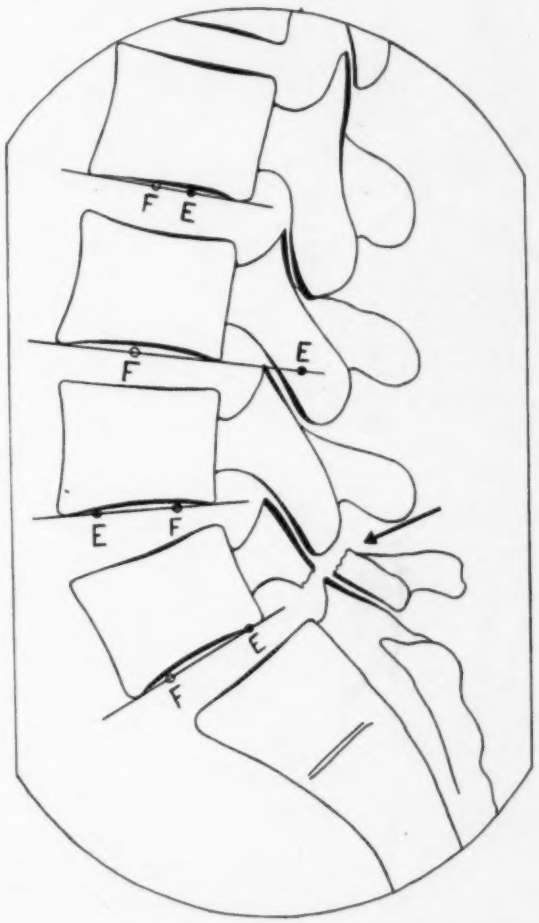

Fig. 10. Spondylolisthesis, grade 2; spread of the fulcra at the fifth disc, spread and reversal of the fulcra at the fourth, articular type of motion at the third, normal motion at the second lumbar disc.

second, the aseptic necrosis of the nucleus, which is also accompanied by loss of water; third, the herniation of the nuclear substance outside of the annulus. All these conditions are associated with loss of nuclear volume and this loss of volume, without a simultaneous shrinkage of the annulus, must result in lowering of the in-

tranuclear pressure. The aseptic necrosis and the posterior herniation of the nucleus are also accompanied by necrosis of the fibrils binding the nucleus to the vertebral bodies and this produces an increased mobility of the nuclear substance.

If one recalls the stresses to which normal nuclei are subjected during the movements of the spine, one must assume that a diseased nucleus will withstand these stresses rather poorly. The poor function of a diseased nucleus is probably responsible for the abnormal motion of the last 13 cases.

It is fully realized that a great deal of investigation will be necessary to establish the exact anatomical basis for the various types of abnormal motion. From a clinical standpoint, however, one should note that abnormal motion was found in a high percentage of the patients who were examined because of low back pain.

It is hoped that the presentation of this method for the roentgen analysis of vertebral motion will stimulate further research in this field.

CONCLUSIONS

1. There is a definite pattern of vertebral motion in the lumbar spine of normal individuals and this pattern can be demonstrated by roentgen examination.

2. Various types of deviation from the normal pattern of motion were observed in a high percentage of the patients examined because of low back pain.

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NON-INJECTION METHOD FOR ROENTGENOGRAPHIC VISUALIZATION OF THE INTERNAL SEMILUNAR CARTILAGE

TECHNIQUE AND ANALYSIS OF RESULTS IN 709 EXAMINATIONS

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THE positive and negative errors in the clinical diagnosis of injuries to the knee cartilages have been estimated at 15 per cent in one clinic (Schaer, quoted by Evans[1]). This undoubtedly is greater when the physician does not have special training or experience in orthopedics. It becomes of special importance in military medicine where such a diagnosis eliminates a man from combat duty and usually from the service entirely. The difficulty of arriving at a correct diagnosis in cases where the history is not reliable for one reason or another is obvious. Routine roentgenography of the knee is rarely helpful except in ruling out bone lesions and radiopaque loose bodies. Therefore, any diagnostic procedure which will eliminate some of these errors should be of great value, especially in military hospitals.

There has been considerable literature written on roentgenographic demonstration of the semilunar cartilages, mostly concerning injection methods with gas and radiopaque solutions. In military medicine these are considered operative procedures which may alter the line of duty status of subsequent developments and therefore would not ordinarily be used as a routine. A method which is nonoperative and simple enough to be performed routinely by a technician becomes of special interest and merits careful consideration.

We are using the method outlined by Reynolds[2] in 1941. Reynolds discovered that up to that time in most of those cases in which subsequent operation proved a pathologic condition of the internal cartilage he had not been able to demonstrate this cartilage in contrast to about 75 per cent visualized in asymptomatic knees. This seemed to him to suggest that non-visualization by his method was evidence of a pathologic condition. Since then Reynolds has analyzed a series of 80 cases with surgical follow-up.[3] Of the 76 cases with cartilage pathology 6 (6.5 per cent) had been reported as normal and 10 (13.2 per cent) as indistinct by his technique. Our own series also proves that a pathological cartilage can be demonstrated at times but indicates also that in a large percentage of those cases a defect may also be visible or the contour of the shadow suggests dislocation (Fig. 4, 8 and 9).

The appearance of the internal cartilage with this technique logically should not differ greatly from that seen in the anteroposterior projection using air injection for contrast and so far as we can tell from the literature this is actually true. Simon, Hamilton, and Farrington[4] in 1936 (using air injection) state that air underlying the internal cartilage is always indicative of a pathologic condition but do not attempt to explain why it should be true. Since with Reynolds' technique a contrast shadow around the cartilage is very infrequent in the presence of a pathologic condition, it would be of interest to know what the results would be if, after air injection, anteroposterior views were made using abduction, traction, and internal rotation as in Reynolds' method.

The same authors list as diagnostic of a "bucket-handle" tear an "air replacement" shadow which separates the peripheral and internal portions of the cartilage. In those cases in which a pathological cartilage can be outlined by Reynolds' technique one

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would expect frequently to see similar findings. Our own series seems to confirm this.

The basic principles of the non-injection method are not new but very little has been written on the subject. Evans[1] in 1940 reviewed such literature to that date. Reynolds incorporated certain maneuvers which apparently have increased the accuracy and at the same time kept the examination within the capabilities of a good technician.

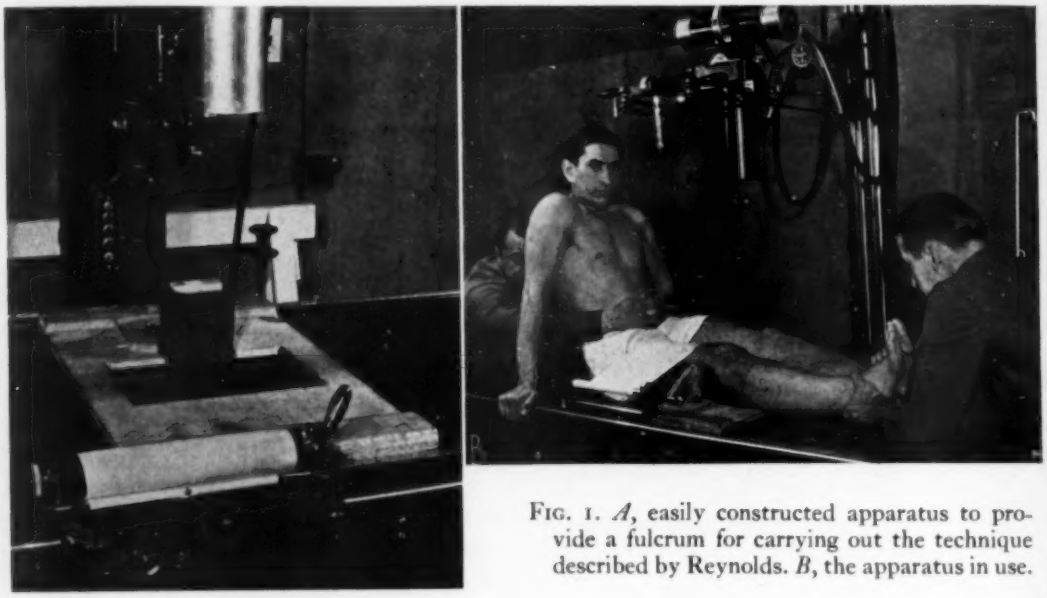

FIG. 1. *A*, easily constructed apparatus to provide a fulcrum for carrying out the technique described by Reynolds. *B*, the apparatus in use.

TECHNIQUE

The technique consists essentially in making an anteroposterior exposure about three seconds after the end of a maneuver consisting of strong traction and firm internal rotation and abduction of the fully extended leg. The thigh is held tightly against the table by a strong immobilization band with a fixed padded fulcrum against its lateral aspect just above the knee. This fulcrum is very important and must be solidly fixed but at the same time easily removable and adaptable to either side of the table for right or left knee.

We have been successfully using a very simple and easily constructed accessory adaptable to any table with or without a Bucky diaphragm (Fig. 1). It consists of a piece of $\frac{1}{4}$ inch plywood about 2 feet long and of width sufficient to fit inside the metal fails at the sides of the table top. If there are no rails on the table, a flange will have to be added to each side of the board to prevent side-play. In the center running lengthwise is a 5×16 inch opening, and midway on one side of this is a padded fulcrum securely attached to the board. By simply turning the board end-for-end it may be used for either right or left knee.

The patient (shoe removed) sits at one end of the board with the knee to be examined fully extended over the distal part of the opening and the padded fulcrum against the lateral aspect of the thigh just above the knee. The compression band is brought across the thigh with strong tension. A wedge (the patient's hand works very well) is placed under the margin of the buttock opposite to the side being examined to prevent a tendency to slide during the abduction maneuver. Counter traction is arranged either by a band around the patient's pelvis and attached to the head of the table or (more easily) simply by having an assistant lean over the head of the table, reach around the patient's pelvis, and pull

just enough to keep the patient from sliding. The patient is urged to relax the thigh muscles. Film and tube in position with an assistant ready to make the exposure, the technician now grasps the patient's instep with one hand and the heel with the other and applies strong traction together with firm internal rotation and abduction of the leg, all in a single combination of motions. Almost immediately after completing the maneuver (about three seconds) he signals for the exposure and, of course, avoids any movement at that time.

Suggested technical factors for an average size knee using par-speed screens and Bucky diaphragm are 40 inches target-film distance, 74 kv., 12 ma-sec., the central ray passing through the distal margin of the patella.

RESULTS OF EXAMINATION

This series includes a total of 709 examinations on 291 patients, all soldiers, during the year ending August 1, 1943. All had symptoms referable to one or both knees, more or less suggestive of a pathologic condition of the cartilage and these special studies were requested by various medical officers in charge of the cases during the course of their clinical observations either in the hospital or out-patient department. Unfortunately, our hope for a substantial series with surgical follow-up could not be realized. However, the results based on clinical history and examination seem to be of value and may, we hope, stimulate interest where more frequent surgical follow-up is possible. Our cases fall into seven groups as follows (Table 1):

Group I. Normal knees. In all cases in which only one knee was symptomatic the normal knee also was routinely examined. There were 284 such asymptomatic knees and in 191 (67.2 per cent) of these the internal cartilage was outlined.

Group II. There were 124 cases in which the clinical findings proved to be negative for a pathologic condition of the cartilage in the case of the knee complained about. Of these, 75 (61.4 per cent) revealed the cartilage outlined in the roentgenograms.

Group III. Cases with a clinical diagnosis of cartilage pathology without surgical follow-up. In this group there were 70 cases of which 58 (83 per cent) did not show the cartilage and 12 (17 per cent) did show it. Review of the roentgenograms in these 12 cases reveals the cartilage shadow to be definitely abnormal in appearance in 8

TABLE I

RESULTS OF EXAMINATIONS

	Cartilage Demonstrated	Cartilage Not Demonstrated	Totals
Group I—Normal, asymptomatic knees	191 (67.2%)	93 (32.8%)	284
Group II—Symptomatic knees with final diagnosis other than pathologic cartilage	75 (60.4%)	49 (39.6%)	124
Group III—Clinical diagnosis of pathologic cartilage without surgical follow-up	12* (17.0%)	58 (83.0%)	70
Group IV—Probable pathologic cartilage but no definite diagnosis made	0	41 (100.0%)	41
Group V—Symptomatic knees with records not available for classification	18 (41.0%)	26 (59.0%)	44
Group VI—Previous knee operation elsewhere but no record as to exact procedure	0	4 (100.0%)	4
Group VII—Pathologic cartilage with operative confirmation	2† (13.3%)	13 (86.7%)	15

* Eight of these showed a defect or thinning of internal portion.
† Both with a defect (Fig. 4 and 5).

TABLE II

GROUP VII—CASES TREATED SURGICALLY

Case	Roentgen Examination with Special Technique	Report of Operation as Recorded	Pathologist's Report
1	Internal cartilage very well outlined on two examinations showing "air replacement" shadow of Simon *et al.* (Fig. 4)	Excision of left meniscus	Gross: a frayed portion of semilunar cartilage 6 cm. in length. Microscopic: cartilage and adjacent connective tissue
2	Internal cartilage very well outlined and showing "air replacement" shadow of Simon *et al.* (Fig. 5)	Loose medial cartilage	Gross: a portion of semilunar cartilage 6 cm. in length having smooth glistening surfaces. Microscopic: essentially intact fibrocartilage
3	Before operation no cartilage shadow was visible. After operation a fuzzy shadow in the position of the cartilage representing either a piece of cartilage not removed or an organized exudate (Fig. 3)	Rupture right internal cartilage, severe, bucket-handle tear	No tissue sent to the laboratory
4	Internal cartilage not demonstrated	Bucket-handle fracture, dislocation of medial internal semilunar cartilage; excised	Gross: a portion of semilunar cartilage 6 cm. in length which is torn along its entire length. Microscopic: well formed fibrocartilage showing a few scattered small areas of mucoid degeneration
5	Internal cartilage not demonstrated	Hemorrhagic fluid in joint, capsular tear internal femoral condyle not involving medial collateral ligament but lying adjacent to cartilage. Excision of internal cartilage	Gross: a semilunar cartilage 8 cm. in length. Its outer thickened border is somewhat ragged. Microscopic: essentially intact fibrocartilage
6	Internal cartilage not demonstrated	Split posterior third internal cartilage; excised	Gross: an irregular portion of semilunar cartilage 7 cm. in length. Microscopic: fibrocartilage showing extensive mucinous degeneration with cyst formation
7	Internal cartilage not demonstrated	Complete bucket-handle tear with displacement into middle of joint. Completely excised	Gross: an irregular torn piece of semilunar 7 cm. in length. Microscopic: dense fibrocartilage showing a few small foci of mucinous degeneration
8	Internal cartilage not demonstrated	Bucket-handle tear right internal cartilage	Gross: two irregular pieces of semilunar cartilage measuring 7 and 4 cm. in length respectively. Microscopic: dense fibrocartilage showing minute areas of mucinous change but an otherwise normal histological appearance

Table II—*Cont.*

Case	Roentgen Examination with Special Technique	Report of Operation as Recorded	Pathologist's Report
9	Internal cartilage not demonstrated	Bucket-handle tear right external semilunar cartilage. Excision of external cartilage	Gross: a torn irregular piece of semilunar cartilage 8 cm. in length. Microscopic: fibrocartilage showing extensive foci of mucinous degeneration
10	Internal cartilage not demonstrated	Excision of right internal cartilage	Gross: the specimen in 3 irregular portions showed only typical cartilaginous tissue. Microscopic: cartilage and adherent connective tissue
11	Internal cartilage not demonstrated	Loose mesial cartilage, left, removed complete and intact	Gross: a portion of semilunar cartilage 6 cm. in length. Microscopic: portions of fibrocartilage showing an essentially intact histological structure
12	Internal cartilage not demonstrated	Bucket-handle tear with displacement into middle of joint	Gross: a semilunar cartilage 6 cm. in length split along its middle portion. Microscopic: fibrocartilage showing occasional small foci of mucoid degeneration
13	Internal cartilage not demonstrated	Bucket-handle injury right internal cartilage	No tissue sent to the laboratory
14	Internal cartilage not demonstrated	Excision of right internal cartilage	No tissue sent to the laboratory
15	Internal cartilage not demonstrated	Bucket-handle tear left internal cartilage. Excision	No tissue sent to the laboratory

with either a defect and "air replacement" shadow or definite thinning of its internal portion (Fig. 8).

Group IV. Cases suspected of a pathologic cartilage but with no final diagnosis. There were 41 cases in the group and in none of them was the internal cartilage demonstrated. The clinical criteria for diagnosis are essentially the same as in Group III but because of lack of any follow-up no final diagnosis was ever entered in the record.

Group V. Cases with records too inadequate for any conclusion but who originally had knee complaints more or less suggestive of cartilage pathology. Of the 44 cases in this group 26 (59 per cent) had no cartilage visible and 18 (41 per cent) showed the cartilage outline.

Group VI. Cases with previous operation elsewhere, presumably for a pathologic cartilage but not confirmed. None of the 4 had a cartilage visible in the roentgenogram. One of these (Fig. 2) had an irregular contrast shadow but no cartilage outline. Another case, which was operated here and is included in Group VII, had no cartilage visible before operation (Fig. 3, *A*). Six months after operation an examination (Fig. 3, *B*) reveals a wedge-shaped shadow almost like that produced by the cartilage though less sharply defined and quite blunt

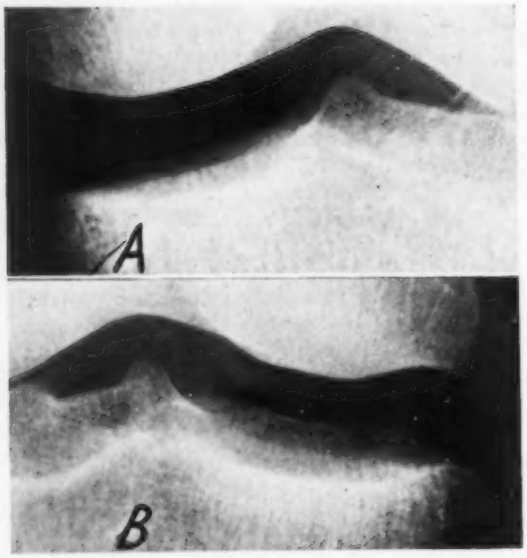

FIG. 2. *A*, asymptomatic right knee showing normal cartilage. *B*, left knee injured ten years ago at which time internal cartilage was removed. There is an irregular contrast shadow with no suggestion of a cartilage outline.

at its internal angle. The operative record states that there was a bucket-handle tear of the internal cartilage which was excised. No tissue was sent to the laboratory and no statement made as to how much of the cartilage was removed. If part of the cartilage adjacent to the capsule had been left, it might easily explain the apparent contradiction. An organized exudate in the space previously occupied by the cartilage is also a possible explanation though less probable. Reynolds[3] also had 2 cases showing what was interpreted as a normal internal cartilage shadow in which the cartilage had previously been removed.

Group VII (Table II). Cases operated for cartilage in this hospital. This group totaled 15 cases and 13 (86.7 per cent) of these showed no cartilage shadow in the roentgenograms with this technique before the operation. Two revealed distinct cartilage shadows (Fig. 4 and 5) and in both of these there was a defect conforming to the "air replacement" shadow. In neither case did the operative record indicate the type of injury found.

RESULTS OF RE-EXAMINATION

In 113 patients one or both knees were examined two or more times with a total of 125 examinations in addition to the first one. Table III shows the results at the second one and third examinations for each of the seven groups.

There were 24 in which the cartilage was outlined in the original examination and all again showed it in the repeat studies.

Initially failing to show the cartilage, 40 asymptomatic control knees were rechecked and in 10 (25 per cent) it became visible. Six of the remainder were examined a third time and half of these then revealed the cartilage. If these percentages were maintained and all of the asymptomatic knees had been re-examined it would be expected that the percentage of success would increase from 67.2 per cent to 75.4 per cent with a second examination. Further improvement would follow a third trial but our series in this group is too small for accurate prediction.

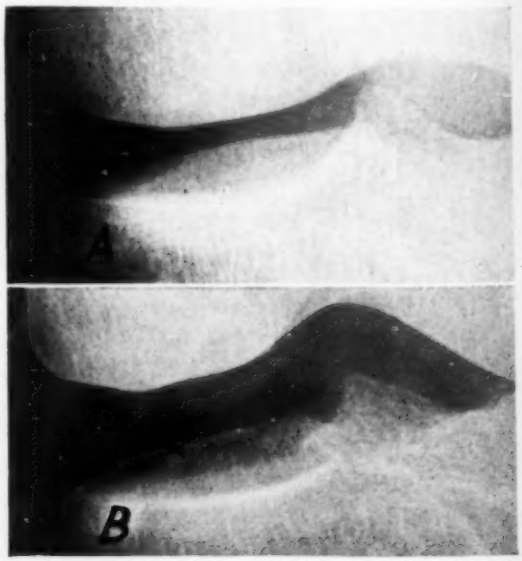

FIG. 3. *A*, Reynolds' technique showing no cartilage shadow. *B*, six months later after cartilage was surgically removed. Note irregular blunt rounded wedge without internal extensions which apparently represents an organized exudate or a piece of the peripheral portion of the cartilage not removed. Without the history correct interpretation would not be possible.

The symptomatic knees (Groups II to VII) included 49 with failure to show the cartilage on initial examination. Eight (16.3 per cent) became visible on second examination and 6 of these were in Group II in which the clinical findings were against

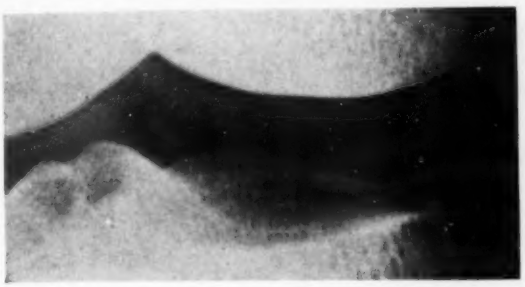

FIG. 4. Cartilage injury with surgical confirmation. Note gap between peripheral and internal portions of cartilage, the "air replacement" shadow described by Simon, *et al.*, in their studies using air injection technique.

a pathologic cartilage. On the other hand, Groups III, IV, VI, and VII (definite or probable pathologic cartilage) had a change from non-visualization to visualization in only 1 out of 27 cases (3.7 per cent) and that one was on the third examination.

In attempting to explain why the initial examination fails and re-examinations succeed in so many cases we must admit that

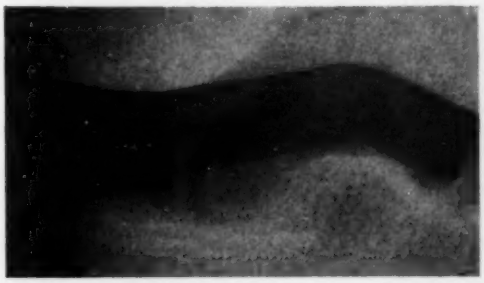

FIG. 5. Cartilage injury with surgical confirmation. Note "air replacement" defect near apex of cartilage wedge.

the experience of the technician making the examination is the most important factor but probably is not the only one. Perhaps some patients are less apprehensive and relax better after an initial experience has shown them what is to be done. Whatever it may be, we believe that in those cases in which the cartilage is not definitely outlined a second or even a third trial is justified.

TABLE III

RESULTS OF RE-EXAMINATIONS*

	Second Examination		Third Examination	
	Cartilage remains not visible	Cartilage becomes visible	Cartilage remains not visible	Cartilage becomes visible
Group I—Normal, asymptomatic knees	30	10	3	3
Group II—Symptomatic knees but final diagnosis other than pathologic cartilage	9	6	2	0
Group III—Clinical diagnosis pathologic cartilage without surgical follow-up	15	0	2	1
Group IV—Probable pathologic cartilage but no definite diagnosis	8	0	0	0
Group V—Symptomatic knees but records not available for classification	6	1	0	0
Group VI—Previous operation but no record as to exact procedure	3	0	1	0
Group VII—Pathologic cartilage with operative confirmation	1	0	0	0

* All cases in this table showed no cartilage shadow in the original examination. There were also 24 cases re-examined in which the cartilage was visible in both original and subsequent examinations.

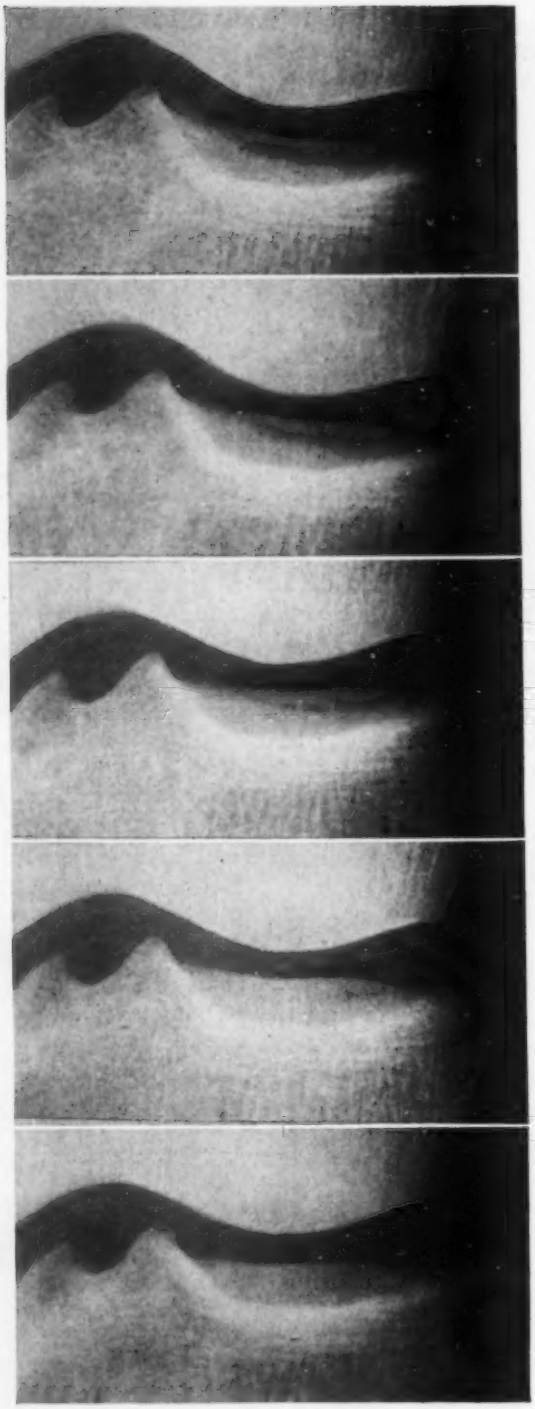

FIG. 6. Experiment demonstrating the gradual disappearance of the shadow and indicating that this shadow is a partial vacuum rather than air. The upper view was made immediately on completion of the maneuver as routinely performed in Reynolds' technique. The other four exposures were made respectively at one minute intervals, the traction, internal rotation, and abduction being maintained continuously.

DISCUSSION

Reynolds states that the cartilage cannot be demonstrated in the presence of effusion regardless of whether or not it is injured and this has also been our experience. Likewise acute tenderness is a contraindication and this should be allowed to subside completely. Otherwise the procedure is without ill effect and in itself causes no pain. It is conceivable, of course, that one could use too much force but none of our cases has complained of anything more

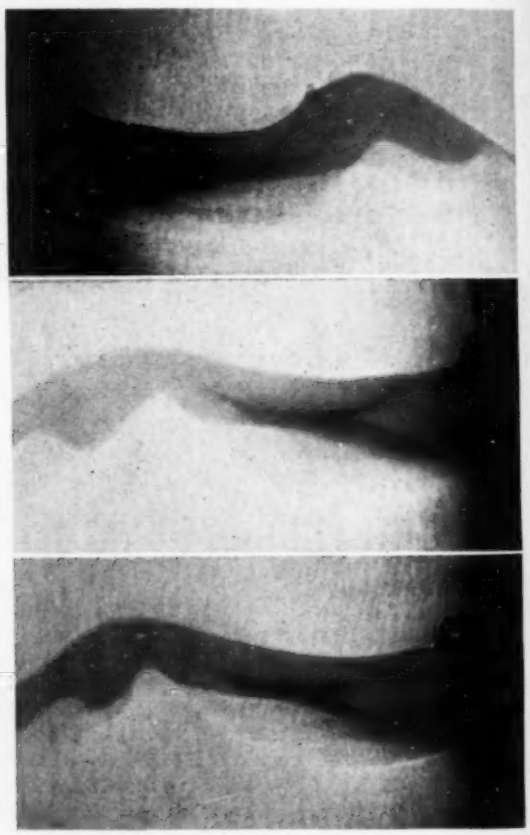

FIG. 7. Normal asymptomatic knees showing variation in the size and shape of the cartilage wedge. Note that either the anterior or posterior horn is projected over the tibia in all these cases. When the two horns are superimposed (as in Fig. 2, *A*) they will be unobscured by bone.

than mild soreness over the mesial aspect of the knee for a few minutes afterward. One soon gets the proper "feel" and can easily tell when maximum abduction has been attained.

In order to determine if there is any importance in the time interval between maneuver and exposure we made a series of exposures in 1 case, the first almost immediately and 4 others at one minute intervals, all the while maintaining the traction, internal rotation, and abduction. The cartilage is sharply outlined in the first and the shadow progressively fades until at three minutes it is no longer visible (Fig. 6). Therefore, the shorter the interval the better, and we allow about three seconds for the patient and technician to become motionless.

This experiment also seems to settle the question as to whether the shadow is produced by air or vacuum. It seems unlikely that air would disappear so rapidly while, of course, vacuum would be expected to be replaced rapidly by the fluid normally in the joint. Abduction places the internal collateral ligament and capsule under tension and since the internal semilunar cartilage is attached to the capsule it is held in position midway between the separated articular surfaces of the tibia and femur allowing both its superior and inferior margins to be outlined. For this reason the air injection method of visualizing the cartilages might give more information if the anteroposterior exposures were made using Reynolds' technique. I know of no instance in which this has been tried.

Fig. 8. Opposite knee of patient in Figure 3. Clinical diagnosis of a pathologic cartilage without surgical confirmation. Note irregularity of inferior cartilage border and thinning adjacent to peripheral portion suggesting "bucket-handle" tear.

Fig. 9. Clinical evidence of injury to internal cartilage. Note the mottled air shadow extending almost to the periphery with no cartilage outline visible. This appearance suggests severe injury with dislocation of the cartilage.

The normal cartilage varies somewhat in size in different individuals but is almost invariably identical in both knees of the same patient. The peripheral portion is wedge shaped with internal extensions representing the anterior and posterior horns very often clearly visible (Fig. 7).

Mottling of the contrast shadow occasionally occurs (Fig. 10) due to synovial fluid and is of no known significance. The cartilage can usually be seen quite well in spite of this though small defects are obscured. Also at times a contrast shadow is seen which is insufficient to outline anything (Fig. 11) and is of no diagnostic value.

Attempts were made to take lateral views but without success. This is to be expected when one considers the thinness and configuration that this contrast layer would present in this projection.

The external cartilage might be expected to become visible by reversing the maneuver from abduction to adduction. Evans was successful in 2 of 30 cases. Our own studies are exclusively of the internal cartilage.

As a result of the abduction necessary to carry out this technique there is separation of the internal femoral and tibial articular surfaces. This widening of the joint space varies considerably in different individuals

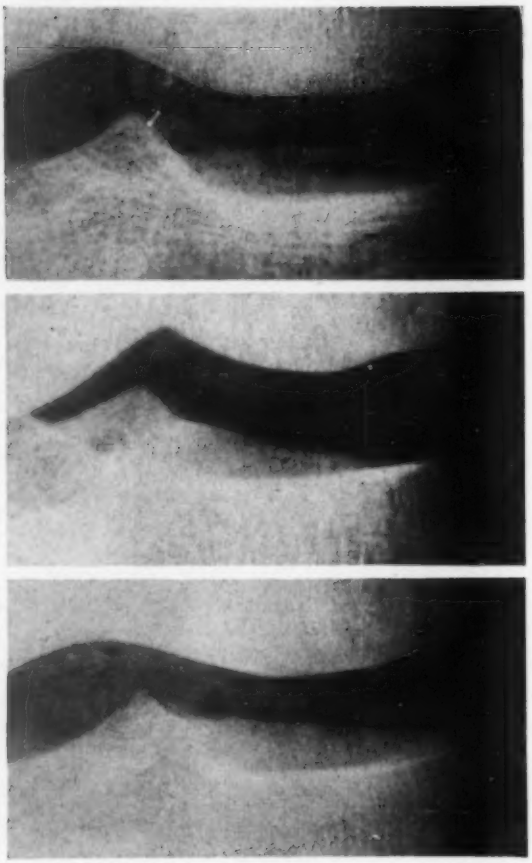

Fig. 10. Examples of mottling of the shadow apparently caused by synovial fluid. The cartilage is outlined but small defects could not be ruled out in these cases.

but is almost invariably equal in the knees of the same patient. In the case mentioned under Group VI and shown in Figure 3 it was noted that the space was greater after operation when the contrast shadow was present than before the operation when none was present. Thinking that a pathologic condition in the internal collateral ligament might be a factor in the success or failure of the technique we chose 50 cases at random and compared the joint space of the healthy knee in which the cartilage was demonstrated with the injured knee which revealed no cartilage shadow. This is best done by superimposing the two roentgenograms. No significant difference was noted. Likewise we have observed that increasing the amount of pressure above that ordinarily used in abduction has little effect on the amount of separation or on the probability of demonstrating the cartilage.

Relaxation of the crucial and collateral ligaments may not be demonstrated in plain roentgenograms unless it is severe. In this series we have observed several cases in which it became obvious only with this technique and was manifested by unusual widening of the joint space and lateral shifting of the tibia (Fig. 12). This point is rather easy to determine from physical examination but it may be of value at times to be able to demonstrate it roentgenographically.

Likewise, narrowing of the lateral joint space may be more accurately portrayed by

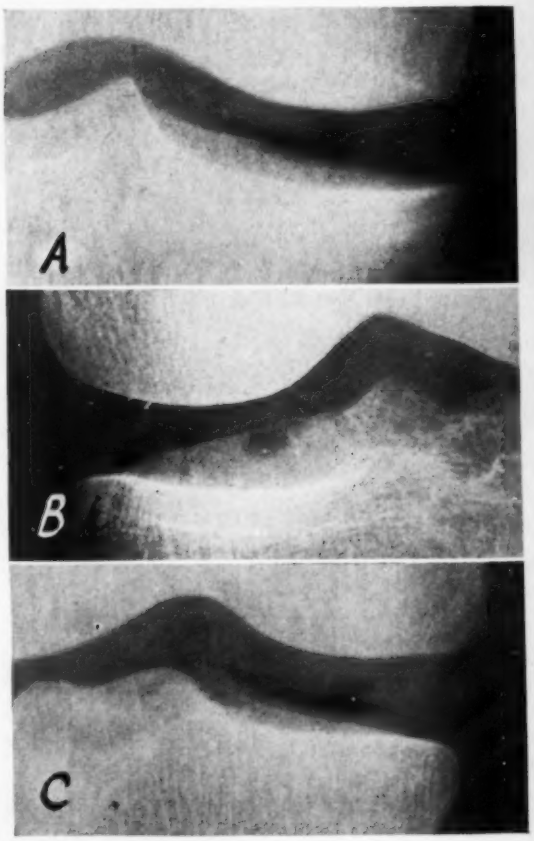

Fig. 11. Examples of shadows occasionally seen without the cartilage being outlined. The diagnostic value of such an appearance is no greater than if no contrast shadow is present. *A*, normal asymptomatic knee; *B*, clinical diagnosis of pathologic internal cartilage; *C*, suspected clinically of a pathologic condition of the cartilage.

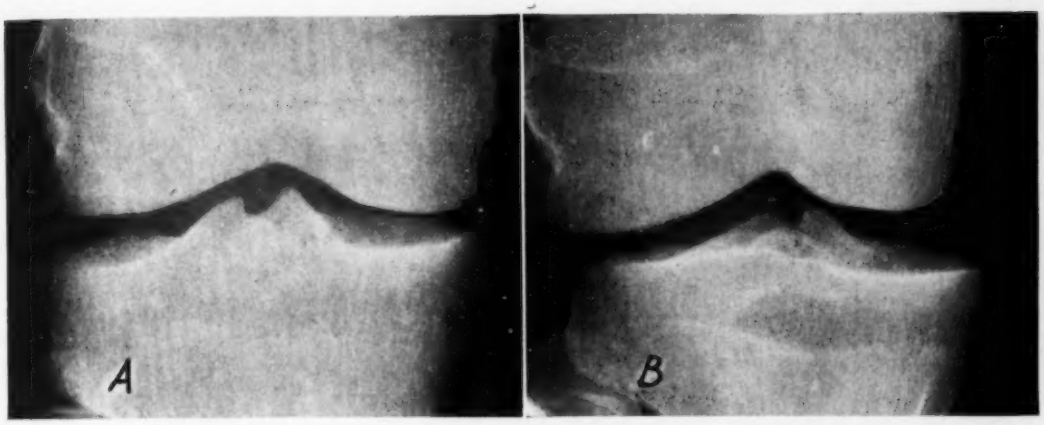

Fig. 12. Relaxation of ligaments. *A*, routine view showing only calcifications in the injured cruciate ligaments. *B*, Reynolds' technique demonstrating luxation of the tibia mesially and more than the usual separation of the mesial joint space.

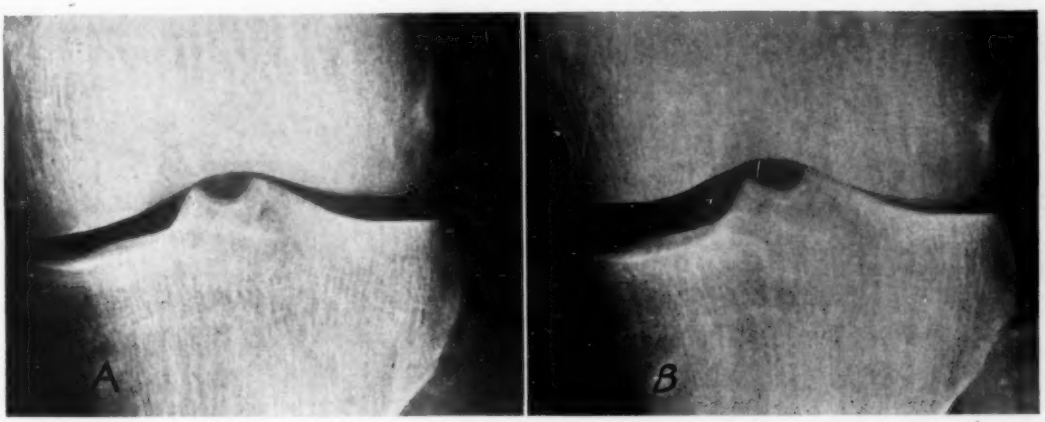

Fig. 13. Example of the value of Reynolds' technique in demonstrating thinning of the lateral joint space. *A*, routine roentgenogram; *B*, same knee using Reynolds' technique.

this technique as a result of the abduction than in ordinary roentgenograms (Fig. 13). This might be expected to occur when the external cartilage is dislocated or there is degeneration of the articular cartilage. Continued observation in this particular might add to the value of this technique, especially in cases of dislocation of the external cartilage.

CONCLUSIONS

1. The technique described by Reynolds for visualization of the internal semilunar cartilage requires careful attention to small details for success and should not be attempted after a recent injury.

2. In a series of 191 normal asymptomatic knees 67.2 per cent revealed the cartilage on the first attempt. Re-examination increased this to 75.4 per cent.

3. In only 10.8 per cent of cases with diagnosis of a pathologic condition of the cartilage (mostly without surgical confirmation) could the cartilage be demonstrated. This indicates that non-visualization is of corroborative value.

4. When an abnormal cartilage is visualized the pathologic condition is often apparent as a defect, thinning, or absence of a distinct wedge (suggesting dislocation).

5. Thinning of the lateral joint space and relaxation of the ligaments of the knee may become apparent with this technique when

not demonstrated by routine views.

6. Improvement in accuracy of interpretation may be expected when a large series of surgically treated cases can be analyzed.

7. Since the procedure has none of the disadvantages of the injection methods its routine use when a pathologic condition of the internal cartilage is suspected gives promise of being of definite value. In the present state of our knowledge the findings should be interpreted with relation to the clinical evidence.

8. Use of this technique when making the anteroposterior exposures after air injection might improve the results of that method.

SUMMARY

The technique described by Reynolds for visualization of the internal semilunar cartilage without injection has been discussed in detail and a simple apparatus for use in connection with it has been described. The results of a series of 709 examinations have been analyzed and examples of normal and abnormal cartilages presented.

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MARCH FRACTURE

AN ANALYSIS OF TWO HUNDRED CASES

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MARCH fractures of the metatarsals have been encountered with increasing frequency in the armed forces and several short reports have appeared in the American and British literature in the past two years.[1,7,16,17,20,22] The clinical syndrome and roentgenologic appearance should be well known by now, and will be mentioned only briefly in this report. However, the mechanism by means of which these fractures occur, and the predisposing causes, if any, have been the subject of so much theorizing and speculation in the literature that the whole question is confused.

It is the purpose of this report to present the results of a study of 200 soldiers who sustained 220 march fractures of the metatarsals between May, 1941 and August, 1943. Nine of these cases have been previously reported.[7] Special attention will be given to possible predisposing causes. The various theories which have been advanced to explain the pathogenesis of march fracture will be discussed.

CLINICAL FINDINGS AND ROENTGENOLOGIC APPEARANCES

The first symptom is usually a dull ache in the metatarsal area, gradually increasing in severity. Only occasionally is the onset abrupt. The pain is present only when the body weight is borne on the foot, and to minimize it, the patient walks with a limp. There is usually some edema of the dorsum of the foot and tenderness is localized to the site of the fracture. No crepitus is felt and active motion at the ankle joint or of the toes is not painful. Relief is obtained by rest and elevation of the foot. In most untreated cases the fracture heals without complication, but in such instances the foot remains tender and painful for many weeks. Rest in bed and local application of an ice bag until the edema subsides, followed by the use of a metatarsal bar on the shoe when walking is resumed, will shorten the period of disability. This is especially true if treatment is begun soon after the onset of symptoms. The experience of the orthopedic department at this hospital indicates that treatment by a plaster cast is not necessary and even delays the soldier's return to full duty. Some of the earlier cases in this series, which were treated with a plaster cast, developed osteoporosis.

One of us[7] has previously suggested that this syndrome may be divided into four stages, based on the roentgenologic findings. In the first stage, during the first seven to ten days after the onset of symptoms, the roentgenogram may reveal no abnormality or only a narrow and incomplete fracture line. Such a fracture may be missed entirely unless the roentgenogram is of excellent quality and is carefully studied. However, in many instances the fracture line is complete, and occasionally is actually comminuted. A fracture line can be demonstrated prior to the appearance of callus formation in almost all patients who are seen soon after they first experience the pain.

In the second stage, usually from one to three weeks after the onset, a loosely calcified, faint, fuzzy callus is seen surrounding the metatarsal in the shape of a spindle. The break in the cortex is almost always visible in this stage. The amount of callus is often out of proportion to the extent of the fracture, but if the fracture is recognized early and weight bearing is prohibited, the subsequent callus formation will be less abundant. If the fracture remains incomplete, the callus may be confined to one side of the shaft.

The third stage reveals the callus to be

more dense, more sharply circumscribed and of smaller volume. The fracture line is frequently still seen. This stage is usually seen two to six weeks after the onset.

The fourth and final stage is represented by diffuse thickening of the cortex of the metatarsal after several months have elapsed.

REVIEW AND ANALYSIS OF THE THEORIES ADVANCED IN THE LITERATURE

All recent papers credit Breithaupt with first describing this syndrome in 1855. He believed that "march foot" was a traumatic inflammation of the tendon sheaths. In 1877 Weisbach[21] thought that march foot was due to a traumatic inflammation of the intermetatarsal ligaments. In 1887 Pauzat[13] stated that a periosteal proliferation was present as the result of irritation from the dorsal fold of the French military shoe. One year later Poulet[14] suggested that a rheumatic diathesis was the underlying cause and in 1891 Martin[8] called it a synovitis and arthritis of the joints of the foot. All of these theories were discredited when, in 1897, Stechow[18] demonstrated roentgenologically that a fracture was present in some of these cases. Schulte[15] in the same year presented similar evidence. Since that time practically all writers have agreed that a fracture is the cause of the symptoms, and speculation then turned to the mechanism by means of which these fractures occurred.

Momburg,[10] in 1904, suggested that an inflammatory change occurred as the result of prolonged elastic bending of the metatarsals. This, he believed, caused periosteal proliferation, which, if continued, resulted in a fracture. Thus, Momburg believed that the periosteal proliferation preceded the fracture.

In 1905 Kirchner[6] stated that a fracture of a metatarsal was always present in these cases. He attributed the fracture to exhaustion of the intrinsic muscles of the foot and the consequent loss of their supportive action. The rôle of the intrinsic muscles of the foot in supporting the metatarsals has been the subject of considerable study by Morton.[12] His carefully worked out evidence indicates that these relatively weak muscles have no significant part in metatarsal support. This theory of Kirchner's is not valid in the light of the evidence offered by Morton.

In 1921, Deutschländer[3] advanced the idea that the basic process in march foot was a low grade hematogenous bacterial periostitis. He based his reasoning on 6 cases, all in women. In these patients periosteal proliferation was present only after a period of several weeks. This theory offers no explanation for the location of the pathologic process. The second or third metatarsal was involved in all 6 of his cases. If this is an embolic phenomenon, as Deutschländer maintained, this localization cannot be explained on the basis of the blood supply to the foot. Furthermore, in one of his illustrations there appears to be a fracture line, and the author admitted that from roentgenologic evidence alone, the entity he described was practically indistinguishable from the march foot of soldiers. There appears to be no valid evidence to sustain the infectious theory as a cause of march fracture.

In 1926 Jansen[5] proposed the circulatory theory. He noted that bony changes occurred only in the areas where the fibers of the interossei arise (i.e., all of the metatarsals except the first and the lateral border of the fifth). He theorized that overfatigue in a weak forefoot causes spasm and swelling of the interossei, stasis of the blood and lymph, thickening of the periosteum and brittleness of the bony tissue of the metatarsals. He believed that subperiosteal hemorrhages occur, are followed by partial absorption of bone and that the bone is weakened by an internal reorganization of its structure and that eventually a fracture occurs.

There are several objections to this theory. First, the explanation for the site of the fracture is unnecessarily complicated. More simply explained, it would appear that the fifth metatarsal is spared because it

bears only a small portion of the body weight in walking. The first metatarsal is not fractured because its heavier structure enables it to withstand the trauma of marching. Second, we have never seen absorption of bone on the roentgenogram before the appearance of the fracture. Dodd[4] has made a similar comment. Third, Jansen's explanation of the mechanism, as does Momburg's, attempts to explain the fact that, at that time, the fracture was rarely demonstrated until periosteal proliferation was seen, and frequently never was demonstrated. This theory supposes that the periosteal proliferation precedes the fracture and indeed that a fracture may not occur in all cases. More recent reports, especially that of Meyerding and Pollock[9] and our own present experience, refute this. The fracture occurs first, and the periosteal reaction which has been so stressed in the earlier literature is simply callus formation. The explanation for the earlier opinion that the periosteal proliferation precedes the fracture probably lies in the technical advances in roentgenography which have enabled the production of roentgenograms of a degree of definition and detail beyond that obtainable at that time. Many fine "hair line" fractures undoubtedly were not visible. It thus appears that the circulatory theory was advanced to explain a sequence of events which has since been shown to be incorrect. Certainly no theory of muscular swelling and venous stasis is necessary to explain a fracture of a metatarsal.

More recently Dodd[4] in 1933, Zeitlin and Odessky[23] in 1935, and Sirbu and Palmer[16] in 1942 have attempted to explain the cause of the fracture on the basis of the disturbed weight bearing incident to a short first metatarsal, the so-called "Morton's foot."

Morton[12] has described a group of four variations from the normal foot, visible roentgenologically, which have become known by his name. These are (1) a short first metatarsal, (2) proximal location of the sesamoids of the first metatarsal, (3) widening of the joint space between the first and second cuneiforms and (4) thickening of the shaft of the second metatarsal. He regarded such a foot as functionally inadequate because when these changes are present the first metatarsal does not bear its proper share of the body weight. As a result, the load is thrown on the other metatarsals, especially the second. Morton explained, and has successfully treated, many cases of metatarsalgia on this basis.

The sesamoids act as weight-bearing points. If they are located proximally (even when the first metatarsal is of normal length) so that they lie behind the head of the second metatarsal, then the same functional effect is achieved as if the first metatarsal itself is shortened. Morton's foot is therefore regarded as occurring in two forms, the "anatomically" short first metatarsal and the "functionally" short first metatarsal, each of which has the same significance. The separation between the cuneiforms is extremely difficult to evaluate roentgenologically, since the slightest variation in the direction of the central ray causes a marked variation in the appearance of the joint space. (For this reason no attempt was made to evaluate this point in the present study.)

Dodd[4] reported a single case which was erroneously diagnosed as sarcoma (an error others[19] have made). He also reviewed the roentgenograms of 14 published cases, including his own, for the presence of Morton's four points. These he found to be present, at least in part, in every case. He therefore concluded that march fracture is "an autotraumatic complication of subacute flat-foot in an architecturally weak (Morton's) foot."

Zeitlin and Odessky[23] also supported the idea that the cause of the fracture was a displacement of the body weight towards the midline of the foot by the anatomic conditions and structure of a weak (Morton's) foot. They favored the name "pied surchargé" indicating an overloaded foot.

Sirbu and Palmer[16] reported 15 cases of march fracture, every one of which had an anatomically or functionally short first met-

atarsal. They stated that the disturbed weight-bearing which resulted from a short first metatarsal was the basic cause of march fracture. This theory will be discussed together with the presentation of the results of the present study, and will be shown to be erroneous.

Moore and Bracher[11] reported 3 cases in 1941. They stated that "Fatigue, overweight, underdevelopment and functional disorders of the foot do not seem to be the underlying causes of this fracture." Although based on only 3 cases, their conclusions are generally substantiated by the findings in the much larger series reported at this time.

The exciting cause of these fractures is an overloading of the bone by rhythmically repeated, subthreshold traumata acting by summation, beyond the ability of the bone to withstand the stress.[2]

It is well known that metals will crack under certain stresses as the result of changes in the crystalline structure. Henschel (quoted by Brandt) studied the fine structure of bone with the spectroradiograph (a method used in metallurgy to study the crystalline structure of metals). He found that in bone, as in "stressed" metals, changes occur in the grouping of the crystalline systems. If the stress continues, cracks or exhaustion fractures may occur. So far as we have been able to determine, no other worker has reported similar studies.

An important fact was brought out in the examination of the soldiers in this series. Many patients volunteered the information that the onset of pain occurred toward the end of a long march. The constant pounding to which the feet are subjected in such long marches is accentuated by fatigue of the calf muscles. It is almost impossible to maintain the same easy stride and springy gait in the twentieth mile as in the first mile, especially when carrying a pack and rifle. The fracture is essentially a fatigue injury, which appears to be best explained on the basis of Henschel's experiments.

What is probably more important, especially from the standpoint of possible prevention, is the question of predisposing factors. It is this problem which has absorbed our major interest.

MATERIAL STUDIED AND THE METHOD USED

Two hundred consecutive patients with one or more march fractures, examined at this Station Hospital, comprise the group studied. They ranged in age from eighteen to fifty-one, but 81 per cent were between eighteen and twenty-nine years old. So far as possible, the following information was noted in every case:

Age of the patient
Length of service prior to the onset of symptoms
Occupation before induction
Branch of service
Site of the fracture
Stage of the fracture when first seen
Body build (slender, medium, heavy)
Length of the first metatarsal in relation to the second
Location of the sesamoid bones of the first metatarsal
Presence of thickening of the cortex of the second metatarsal
General structure of the foot (slender, average, broad)
Abnormalities of foot structure or evidence of systemic disease

A control group consisting of the roentgenograms of the feet of 400 soldiers was studied. These were selected from the files on the basis of a single criterion. That is, that they were the roentgenograms of soldiers who had the misfortune to suffer a single injury of such severity that the examining medical officer suspected a fracture, and had therefore ordered a roentgen examination. These roentgenograms were not inspected before they were selected for the control group, but were chosen from the files solely on the basis of the statement of the examining officer (on the "x-ray request form") that a single injury had been sustained. Of these 400 soldiers, 165 actually had a fracture due to that single trauma; the remaining 235 did not. This control group is composed of soldiers of essentially

the same age and stage of training, and are drawn from the same military organizations as the march fracture group. The only difference is the manner in which the injury occurred. Such a group is neither more nor less likely to have abnormal feet than the average run of soldiers in the same organizations, and was therefore deemed a true control.

The same roentgenographic technique was used throughout. Dorsoplantar and oblique roentgenograms were made at 36 inch distance, employing a small focal spot and a cardboard film holder. Additional views were made as indicated.

RESULTS

(a) *Length of Service.* The length of service prior to the onset of symptoms varied from one month to seven years and ten months, but 80 per cent of the fractures occurred during the first six months of service. The mode, which represents the typical case, was the three to four month group. Since approximately one month is consumed by the initial furlough granted to selectees at the time of this study, and by the time needed to process them, to transport them to their place of duty and to organize them into units, it is evident that the typical patient had only two or three months' training at the time of the onset of the pain.

Ten soldiers had been in the regular army for over twenty months. In most of these instances, questioning revealed that the soldier had been recently transferred from a sedentary job to an organization undergoing intensive training.

(b) *Occupation Prior to Induction.* In every case an attempt was made to determine the amount of walking or standing the individual's job had required. These were then classed as sedentary or active in relation to the amount of strain the feet had been accustomed to in the past. Excluding the Regular Army soldiers, 44 per cent had pursued a vocation which had required much standing or walking, and 56 per cent had followed a sedentary occupation. Thus it is seen that the occupation prior to induction has no relation to the occurrence of a march fracture.

There are several reasons for this. The strain placed on the feet in military service is entirely different from that experienced in civil life. Even those who have arduous jobs in civil life can almost always sit down and rest for a few minutes when they become fatigued. Furthermore, a farmer does most of his walking on relatively soft soil, whereas a soldier does much of his marching on roads or hard drill fields. There is also the added factor of the pack and rifle which materially increase the weight the feet have been accustomed to bearing.

(c) *Branch of Service.* The great majority of the soldiers in this series were infantrymen, a percentage which was much higher than the average proportion of infantry troops present on the post. This is not surprising, since in spite of the mechanization of the modern army, the infantryman is still primarily a foot soldier.

(d) *Site of the Fracture.* The right foot was the site of the fracture in 105 instances, the left in 86 and both feet in 9 cases. In all bilateral cases the fractures occurred at different times. Fractures of more than one metatarsal in the same foot were present in 9 soldiers, in some cases apparently having occurred at the same time. Two patients had two metatarsals fractured in one foot and one in the other. Thus a total of 220 fractured metatarsals was seen in these 200 patients. These were distributed among the metatarsals as follows:

SITE OF THE 220 FRACTURES

	Number	Per Cent
Second metatarsal	98	44
Third metatarsal	112	51
Fourth metatarsal	10	5
Total	220	100

This is a somewhat higher percentage of fractures in the third metatarsal than has been noted in most previously reported

FIG. 1. Left foot, oblique view. A narrow, incomplete fracture line is visible (arrow) in the distal portion of the third metatarsal. No callus is present. This is a march fracture, first stage.

series. No fractures were present in the first and fifth metatarsals.

(e) *Stage in Which First Seen.* At the time of the first roentgenographic study the fractures occurred in the various stages as follows:

STAGE IN WHICH FIRST SEEN

	Number	Per Cent
No fracture diagnosed	25	11
First stage	113	52
Second stage	57	26
Third stage	25	11
Total	220	100

All of the patients on whom no diagnosis of a fracture was made on the first examination were re-examined within a few days because of continued pain, and the fracture was then discovered. The original roentgenograms were reviewed in every case and it was agreed that the diagnosis could have been made, or at least suspected, in 10 instances. In the remaining 15 roentgenograms (7 per cent of all fractures) there was no evidence of a pathologic process even when the site of the fracture was known. It is possible that in some of this latter group the fractures had not yet occurred at the time of the original examination.

When first seen the fractures varied in extent from a barely visible hair line to easily seen complete fractures; 16 of these were comminuted.

(f) *Body Build.* It was possible to estimate the body build in 198 cases. These were distributed as follows:

BODY BUILD
198 Cases

	Cases	Per Cent
Slender	67	34
Medium	92	46
Heavy	39	20
Total	198	100

Since this does not vary strikingly from the distribution found in any group of young males, it seems that march fractures occur without relation to the body build.

(g) *Short First Metatarsal.* In every instance of bilateral fracture the feet were symmetrical. Therefore, in such cases only one foot was counted for the purpose of estimating the incidence of a short first metatarsal.

According to Morton, the weight-bearing axis of the foot during walking or running is a line midway between the first and second metatarsals. A line drawn tangential to the distal tip of the first metatarsal, and perpendicular to this axis should normally cross the second metatarsal within 3 mm. of its distal tip. Therefore, the first metatarsal was considered to be "anatomically" short if such a line was 3 mm. or more proximal to the distal tip of the second metatarsal. The sesamoids were considered as proximally located ("functionally" short first metatarsal) if a transverse line through the center of the more distal sesamoid fell behind the entire head of the second meta-

tarsal. (These criteria were suggested to us by Morton.)

The incidence of a short first metatarsal among the march fracture patients and a comparison with the control group is as follows:

INCIDENCE OF SHORT FIRST METATARSAL

	March Fracture Cases 200 feet		Control Cases 400 feet	
	Feet	Per Cent	Feet	Per Cent
Anatomically short first metatarsal	42	21	103	27
Functionally short first metatarsal	60	30	81	19
Total	102	51	184	46

This is far short of the 100 per cent incidence reported by Dodd and by Sirbu and Palmer. In addition, there is no significant difference in the frequency of occurrence of a short first metatarsal between the march fracture and the control group. From these figures it is concluded that a short first metatarsal is not a predisposing cause of march fracture.

FIG. 2. Right foot, oblique view. A comminuted fracture of the distal portion of the third metatarsal is present (arrows). This is a march fracture, first stage, comminuted. It is representative of 16 such fractures encountered in this series.

FIG. 3. Left foot, dorsoplantar view. There is a spindle of loose, thinly calcified callus, with fuzzy margins, around the distal portion of the third metatarsal (arrows). The fracture line can be seen only with difficulty. This is a march fracture, second stage. It is this type of abundant callus which in the past has led to erroneous diagnoses of neoplasm. Note that the mid-points of the sesamoids (retouched for reproduction) are on a plane which falls behind the head of the second metatarsal, although the shaft of the first metatarsal is of normal length. This is an example of a "functionally" short first metatarsal.

At first glance, the percentage of a short first metatarsal (46 per cent) in the control group may seem high. However, Morton[12] stated that "... short or unstable first metatarsal bones are to be found in many feet that have never sensed any related discomfort ... nevertheless these factors must be classed as potential causes of foot disability ..."

FIG. 4. Right foot, dorsoplantar view. A spindle of dense, sharply circumscribed callus is seen around the distal portion of the shaft of the third metatarsal. The fracture line is no longer visible. This is a march fracture, third stage. The line drawn between the first and second metatarsals represents the weight-bearing axis in the act of walking (Morton). A line drawn tangential to the tip of the first metatarsal, perpendicular to this axis, shows that the first metatarsal is of normal length. The foot is slender in relation to its length. The cortex of the second metatarsal is thickened in comparison with that of the fourth metatarsal.

As further confirmatory evidence of the absence of any relation between march fracture and a short first metatarsal, the location of the march fractures in those cases with a short first metatarsal was compared with the distribution among the men who had a normal first metatarsal, as follows:

EFFECT OF PRESENCE OF SHORT FIRST METATARSAL ON SITE OF FRACTURE

Location of 220 Fractures	Short First Metatarsal Present	Normal First Metatarsal Present
Second metatarsal	46%	42%
Third metatarsal	51%	50%
Fourth metatarsal	3%	8%
Total	100%	100%

It is evident that the presence of a short first metatarsal has no material effect on the site of the fractures. A short first metatarsal is presumed to throw a greater proportion of the load on the second metatarsal. Therefore, if there is any relationship between a short first metatarsal and march fracture, one would expect a greater proportion of such fractures to occur in the second metatarsal when a short first metatarsal is present. However, the table presented demonstrates that the location of these fractures is not significantly affected by the presence of a short first metatarsal. This fact further supports the conclusion that a short first metatarsal is not a predisposing cause of march fracture.

(h) *Thickening of the Cortex of the Second Metatarsal.* The cortex of the midportion of the shaft of the second metatarsal was compared with the corresponding area on the fourth metatarsal. On this basis, the occurrence of thickening of the cortex was as follows:

THICK CORTEX, SECOND METATARSAL

	March Fracture Cases 200 feet	Control Cases 400 feet
Overall incidence	83%	79%
Of those with a short first metatarsal	87%	89%
Of those with a normal first metatarsal	80%	70%

Thickening of the cortex of the second metatarsal is thus seen to be very frequent. This higher incidence in those feet which have a short first metatarsal bears out Morton's idea of the relationship between the two. Morton has suggested that when the cortex of the second metatarsal is thickened, in the absence of a short first meta-

tarsal, then it is likely that hypermobility of the first metatarsal (separation between the first and second cuneiforms) is present. However in 70 per cent of our control cases with a normal first metatarsal there was some thickening of the cortex of the second. This seems rather high to be explained on this basis alone. There may be some relation to the presence of foot strain over a period of years. In general, the presence of a thickened cortex of the second metatarsal is so common that it must be regarded as the usual, if not the normal picture.

(i) *Width of the Foot.* This was assessed empirically, i.e., no absolute measurements were made. Each roentgenogram was viewed in an attempt to decide whether the foot was narrow in relation to its length. In such cases the metatarsal shafts were almost uniformly narrower than in the average run of feet. Of the 200 feet in the march fracture group 44, or 22 per cent, were considered to be of the slender type. The remainder were of average or greater than average width. In the control group of 400 feet only 15.5 per cent were considered to be of the narrow type. This difference is probably not significant.

(j) *Other Findings.* Seven cases of mild or moderate hallux valgus and 6 instances of hypertrophic spur formation at the distal end of the first metatarsal were encountered. An occasional case with mild or moderate pes planus and 3 with pes cavus were seen. There were no instances of osteoporosis nor was there evidence of any systemic disease such as rheumatoid arthritis or gout. All of the patients appeared to be well nourished.

FIG. 5. Left foot, slightly oblique view. There is a tiny cap of callus on the medial side of the distal portion of the second metatarsal (arrows). A tiny, incomplete fracture line is present under this callus. This is representative of the second stage, in which the fracture has remained incomplete, and the callus is confined to one side of the shaft. The first metatarsal is clearly seen to be "anatomically" short.

SUMMARY

The clinical syndrome, the roentgenologic appearance and the treatment of march fracture have been briefly presented. The literature has been reviewed, and the many theories advanced to explain the pathogenesis of march fractures have been discussed and their shortcomings noted.

The immediate cause of the fracture is the rhythmically repeated, subthreshold traumata incident to marching, which, acting by summation, reach a point beyond the ability of the bone to bear stress. Fatigue of the calf muscles causes these subthreshold injuries to be accentuated. Henschel's experiments indicate that as the result of these subthreshold traumata a change in the crystalline structure of bone occurs. If the stress and strain is continued, a fracture occurs.

The results of the study of 200 soldiers with 220 march fractures of the metatarsals are reported. A control group of 400 cases was also studied.

These fractures usually (80 per cent) occur within the first six months of training, especially among infantrymen. The second and third metatarsals are most frequently

involved. One-half of the fractures are seen and can be diagnosed before callus formation occurs. The fractures vary in extent from a narrow "hair line" to actual comminution. A small proportion (7 per cent) cannot be diagnosed on the first examination but will be apparent on re-examination after a few days. Careful study of technically perfect roentgenograms is a requisite.

The nature of the soldier's previous occupation and his body build have no relation to the cause of march fracture. The presence of a short first metatarsal is not a predisposing cause. A slender foot (in relation to its length) does not appear to be a significant predisposing cause.

CONCLUSIONS

1. There appears to be no single factor which occurs with sufficient regularity to be considered a predisposing cause of march fracture.

2. The presence of a short first metatarsal is not a predisposing cause.

3. While the actual exciting cause of the march fracture is apparent, none of the theories advanced in the literature adequately explain the pathogenesis, with the exception of Henschel's statement that a change in the crystalline structure of bone occurs under continued low grade stress. This is a fatigue fracture.

4. These fractures will continue to occur in the course of training soldiers. The most important fact to be emphasized is that early recognition and proper conservative treatment restore these men to duty with a minimum of lost time.*

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* Since this paper was submitted for publication, we have seen 46 additional cases with a total of 50 march fractures. Thus, the total number studied is now 246 soldiers, who sustained 270 fractures. The statistics presented and the conclusions drawn have not been altered by the additional cases seen.

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PEPTIC ULCER OF THE GREATER CURVATURE OF THE STOMACH*

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BENIGN ulcers of the greater curvature of the stomach are so extremely rare that lesions, especially niches, found in this location are usually considered to be malignant until proved otherwise. A review of the literature, both early and recent, testifies to the rarity of such occurrence. It also reveals that the real incidence of ulcers of the greater curvature is unknown because most of the reported cases were not proved histologically nor followed up adequately.

Finsterer and Glaessner[5] apparently were the first to call specific attention to this important subject with their review of all the cases up to 1914. They found 36 reported as ulcer on the greater curvature. Blaine,[1] in 1925, contributed 3 additional cases. David[4] reviewed all the cases from 1914 to 1928. These included 2 additional cases of Sutherland[15] in 1925, and excluded those reported by Blaine. He found 24 reported as ulcers of the greater curvature. Sproull,[14] however, in an excellent critical analysis of these foregoing authors' cases and others up to 1931, stated that according to his understanding of peptic ulcer only 10 of all these cases proved to be ulcers of the greater curvature, both by histologic examination and by location. He then cited one case of his own to caution against the danger of such unproved diagnoses. This was a woman, aged twenty-four, with a peptic ulcer syndrome of one year duration. Roentgenograms revealed a definite lesion on the greater curvature. At operation, the surgeon thought it was benign, and it was locally excised. Microscopically it proved to be carcinomatous and the patient died two years later of a large, inoperable carcinoma.

Significantly, Sproull concluded from his own experience and that of the leading roentgenologists of his time, that it was unwise for a roentgenologist to diagnose a lesion on the greater curvature as benign. The chance of the diagnosis being correct, he stated, was one in a million. Obviously, he counselled against the medical treatment of any lesion on the greater curvature.

In the following years, Holmes and Hampton[8] in 1932 studied 202 autopsy cases and did not find a single instance of an ulcer of the greater curvature. They also quoted Orator who studied 330 cases of gastric ulcers from Eiselberg's clinic, both grossly and histologically, and found no benign ulcers of the greater curvature.

In 1933, Bowers and Rivers[3] reviewed the records of 617 benign cases of gastric ulcer in which exploration had been done and found none on the greater curvature. In another series of 240 cases, 120 benign ulcers and 120 malignant lesions, they found 4 on the greater curvature. All of these were malignant. Interestingly, they concluded that the closer an ulcer came to the pylorus or greater curvature, the more likely it was to be malignant.

Matthews,[13] in a painstaking critique, brought the literature up to 1935. He concluded that only 22 cases were reported in sufficient detail to warrant a diagnosis of true greater curvature ulcer. Of these, however, further study revealed that only 10 were proved histologically. He contributed 2 additional cases of his own, both on the greater curvature, one 12 cm. and the other 14 cm. from the pylorus. Both of these were proved microscopically, and both were well on follow up, one after five and a half years

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FIG. 1. Immediate roentgenogram (January 11, 1943), showing a large, irregular, polypoid-like filling defect in the antral region involving the greater curvature. Note the niche and also the accentuated and convergent rugae.

and the other after fifteen months. This latter case had perforated through the gastrocolic omentum.

In the recent literature van Buchem[16] added a single case in 1938, of a large crater on the greater curvature confirmed at operation and histologically benign. The patient was well after a three year follow up. Williams,[17] in a concise but nevertheless pointed paper in December, 1941, presented 2 more cases, both seen at autopsy and histologically confirmed. This brought the total of proved cases of ulcer of the greater curvature in the entire literature to fifteen. His first case had a 1.5 cm. ulcer about 0.5 cm. from the pylorus on the greater curvature of the prepylorus. It had caused a marked degree of pylorospasm producing a large six hour residue. A diagnosis of carcinoma had been made. The second case revealed a large ulcer, 4 cm. in diameter, 6 cm. from the pylorus with smooth undermined edges, astride the greater curvature, which had extended posteriorly to the pancreas.

At the Bronx Facility of the United States Veterans Administration, the case herewith reported was recently treated. Even though exact statistics are not available, it was the first case of benign ulcer of the greater curvature encountered among several thousand peptic ulcers diagnosed roentgenologically and among several hundred which came to surgery. Because of its rarity and because of several interesting and intriguing features in its diagnosis, the case is reported in some detail.

REPORT OF CASE

P. P. J. (No. 51649), white male, aged forty-nine, was admitted on December 30, 1942, with a history of having had "stomach trouble and indigestion" for the past ten to twelve years. This consisted of epigastric pain and discomfort a few hours after meals. At times he would

FIG. 2. Right oblique position (January 11, 1943), revealing the area of defect along the greater curvature with prominence of the large ulcer niche.

vomit when this occurred. He was often awakened at night by this pain, which was local and did not radiate. He had been treated at various times for an ulcer of the stomach, under which treatment he went along fairly well, until August, 1942. At that time he had a severe gastric hemorrhage which necessitated three blood transfusions at a private hospital. After recuperating from this, he was hospitalized at the United States Veterans Facility at Togus, Maine, from December 3 to 29, 1942, where, after a complete examination he was referred to our hospital with a diagnosis of carcinoma of the stomach. He had lost about 40 pounds in the past five months, but in the last three to four weeks he claimed he had gained back 15 pounds and felt generally stronger. However, his appetite was still poor. His bowels were regular and stools were not tarry.

Physical Examination. This revealed a white male who looked chronically ill and somewhat anemic in appearance. The sclerae and mucous membranes were pale in color. The general examination was essentially devoid of positive findings. There were no palpable nodes in the neck. The liver and spleen were not palpable nor were there any other abdominal masses present. Rectal digital examination revealed no shelf and the prostate was within normal limits. The patient weighed 137 pounds and his temperature, pulse and respiration were normal.

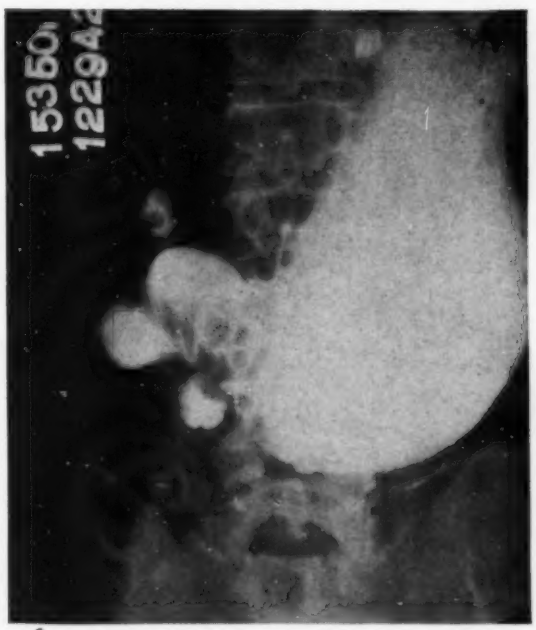

Fig. 3. Immediate roentgenogram (December 29, 1942) from previous hospitalization. The stomach is more dilated. The accentuated rugae clearly converge toward the ulcer niche on the greater curvature.

Fig. 4. Five hours after ingestion of barium meal (December 29, 1942). The defect along the greater curvature is still visible and the ulcer crater is delineated very plainly by the barium.

Laboratory Data. On December 30, 1942, the blood count revealed a secondary anemia. The hemoglobin was 52.9 per cent, erythrocytes 2,990,000, leukocytes 9,000, with a differential count of 66 per cent polymorphonuclears, 30 per cent lymphocytes, 2 per cent monocytes and 2 per cent eosinophiles. On January 16, 1943, the hemoglobin was 51.4 per cent, the erythrocyte count was 3,400,000 and the leukocyte count 6,700. Several urine specimens were within normal limits. Several specimens of stool were positive for occult blood and negative for ova and parasites. The blood Wassermann and Kahn tests were negative. Gastric analysis one hour after an Ewald test meal showed a free HCl of 57 units, a total acidity of 70, acid salts of 6, no organic acids and no Boas-Oppler bacilli present. Report of the gastric analysis done at the previous hospital one month earlier revealed a free HCl of 35 units, a total acidity of 55, combined 11, no lactic acid and was positive for occult blood.

Roentgen Examination. A gastrointestinal series done on January 11, 1943, revealed the

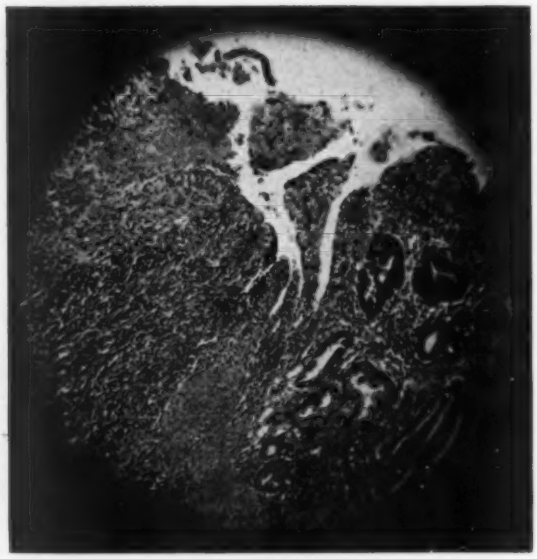

FIG. 5. Photomicrograph (×120) of the margin of the ulcer. There is no evidence of malignant change. Note transition from glandular mucosa to erosion of the ulcer.

following: The esophagus was normal; the stomach was slightly dilated. The greater curvature in its distal half was irregular. This was chiefly due to a large polypoid-like defect in the antral region, 5 cm. in diameter. Below this area of defect was a niche on the greater curvature, measuring 2.5 cm. in diameter, which probably represented an ulcer crater (Fig. 1 and 2). The rugae surrounding this area were prominent and seemed to converge toward it. On roentgenoscopy they could not be effaced. Peristaltic waves did not pass over this area. A definite meniscus sign could not be demonstrated. At six hours, there was a small gastric residue which still outlined the crater, and the remainder of the meal lay in the terminal ileum. At twenty-four hours, the barium was in the colon which was fairly well filled and appeared normal.

In connection with the roentgen findings, it is interesting to note the roentgenograms taken at the previous hospital two weeks earlier (December 29, 1942) because they bring out more clearly the large ulcer niche on the greater curvature (Fig. 3 and 4). Unfortunately, we did not have these roentgenograms at the time of operation. In addition to the gastric findings, both sets of roentgenograms also showed a chronic duodenal ulcer as evidenced by deformity of the duodenum and definite gastric retention.

Operative Findings. Principally because of the location and size of the lesion, a diagnosis of carcinoma of the greater curvature was made and the patient was prepared for surgery with transfusions, and so forth. On January 21, 1943, under spinal anesthesia, an exploratory operation was done. Essentially the main findings were as follows: A large ulcer 5 cm. in diameter was found astride the greater curvature with one leg, so to speak, extending somewhat on to the posterior wall. In its center was a large crater, which could be felt by invaginating the stomach wall with the finger. The margins of the ulcer were hard and indurated but regular. The transverse colon and gastrocolic ligament were drawn up beneath the posterior wall of the stomach as a result of some sort of a fibrotic, indurated process. The liver and other viscera were explored and showed no evidence of metastases. One small node was felt on the lesser curvature. Since the surgeons could not tell by gross inspection alone whether the ulcer was benign or malignant, an incision was made in the anterior wall of the stomach to ascertain this by biopsy and frozen section, and also to see more clearly the extent of the ulcer. It was then seen that the rugae surrounding the ulcer were hypertrophied and edematous and stood out rather stiffly, and converged toward the ulcer. The mucosa was definitely thickened. The first portion of the duodenum revealed

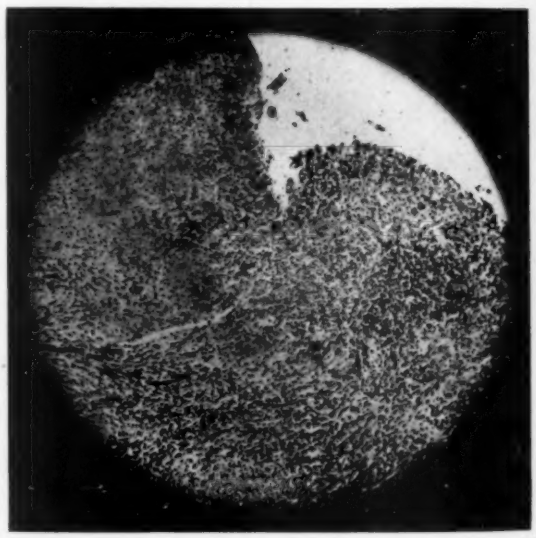

FIG. 6. Photomicrograph (×110) of the base of the ulcer. There is no evidence of malignancy; only a chronic inflammatory process is present down to the muscularis.

scarring and dense adhesions, evidence of a former duodenal lesion, probably ulcer.

Since the frozen sections were reported suspicious for malignancy and because of the posterior extension, it was deemed wise to do a subtotal gastric resection. Approximately two-thirds of the stomach was removed and the gastrojejunostomy attached ante-colically. In addition, an obstructive resection of the mid-portion of the transverse colon and attached greater omentum was done. The remaining colon was colostomized and on March 15, 1943, following preliminary crushing of the spur, the colostomy was suppressed.

Pathologic Findings. The removed portion of the stomach measured 14 cm. in length. At the distal end, 6 cm. from the pylorus, and on the greater curvature was an oval defect 5 cm. in diameter with its posterior portion extending slightly on to the posterior wall. The mucosa about the ulcer was hypertrophied and the rugae edematous. The bottom or the crater of the ulcer was involved in an indurated fibrotic process which evidently had penetrated or perforated through the stomach at one time, and involved the gastrocolic ligament and the serosal surface of the transverse colon at the midpoint of the resected specimen, which itself measured 12 cm. in length. The small lymph node was not grossly characteristic of any pathologic condition.

Histopathology. Several sections through various sites of the ulcer (margins, sides and base) revealed no evidence of malignant change (Fig. 5 and 6). The mucosa, submucosa, and muscularis were infiltrated by numerous lymphocytes and plasma cells, evidence of chronic inflammatory changes. Sections through the transverse colon showed no malignant changes. The chronic inflammatory process had invaded the serosa and muscularis and many eosinophiles were also seen. The lymph node showed only chronic inflammatory lymphoid hyperplasia (Fig. 7).

The diagnosis, pathologically, was penetrating peptic ulcer. These conclusions were verified by Dr. Fred Stewart of Memorial Hospital, our consulting pathologist.

Subsequent Course. Following the resections and suppression of the colostomy, the patient made an uneventful recovery and was discharged on April 6, 1943. He had no complaints referable to the gastrointestinal tract and regained 15 pounds lost during the hospital stay. When last heard from, six months after discharge, the patient was feeling well, had not lost any weight and had had no gastric symptoms.

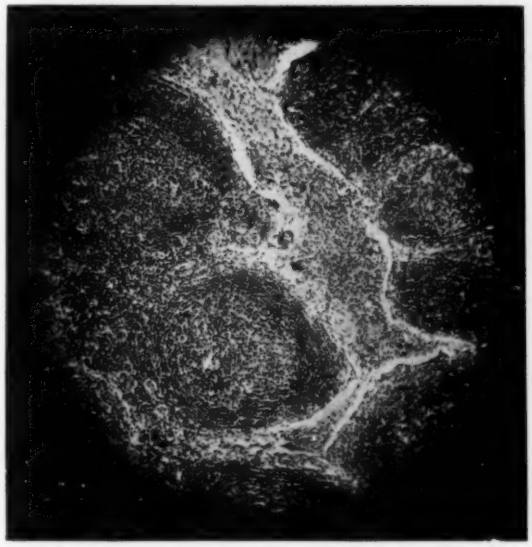

Fig. 7. Photomicrograph (×110) of small node found on the lesser curvature. No malignancy is present.

DISCUSSION

In the case reported there were several interesting features in the differential diagnosis which confronted us, and which merit review. Were we dealing with a large benign ulcer or was it a malignant tumor which, mainly because of its size and location, demanded immediate surgical intervention, rather than a period of medical treatment? To answer this satisfactorily, the many features which are of value in an attempt to establish a differential diagnosis between benign and malignant gastric ulcer had to be considered.

As Eusterman[7] has pointed out, among those that favor benignancy are long duration of symptoms (ten years or more), age of patient (thirty years or less), free hydrochloric acid in the stomach contents (40 units or more), local tenderness on roentgenologic examination, and an hour-glass type of deformity of the stomach. Those symptoms and signs that favor malignancy are late onset in an elderly patient, an irregular syndrome, achlorhydria associated with obstruction, the meniscus sign-com-

plex and the visualization of a large and irregular niche on roentgenologic examination, and the location of the ulcer in the prepyloric area, on the greater curvature, or on the posterior wall of the stomach. Thus, in the case reported, criteria of both benignancy and malignancy were present. Favoring benignancy were the history of long duration of peptic symptoms (ten to twelve years), the episode of severe gastric hemorrhage with recovery, free hydrochloric acid in the stomach contents of 57 and 35 units on two occasions, together with a high total acidity, and the accentuation and convergence of the adjacent gastric rugae toward the ulcer on roentgenologic appearance and the absence of a definite meniscus sign-complex. In favor of malignancy were the age of the patient, forty-nine years, a poor appetite, a definite secondary anemia, loss of 40 pounds in weight in five months, some gastric retention and a large niche located on the greater curvature.

The weight of evidence pointed heavily toward malignancy; yet, considering all the criteria, as Eusterman has emphasized, great caution is necessary in any decision concerning malignancy, because malignant gastric ulcer may successfully mimic a benign lesion. Sara Jordan,[2] however, and others have repeatedly stated that "neither the size of the ulcer nor the age of the patient, nor the presence of normal acid or hyperchlorhydria should lessen our suspicion of carcinoma."

In view of the foregoing, the differential diagnosis narrowed itself down to a consideration of two principal features, the size and location of the ulcer. The size of the entire ulcer was large, measuring 5 cm. in diameter, and the size of the ulcer crater itself slightly over 2.5 cm. in diameter. It is generally known that the larger the ulcer, the greater the chance of malignancy. MacCarty[12] in the Carman lecture of 1940, supports this by stating that at least 90 per cent of all chronic gastric ulcers larger than a quarter (2.5 cm.) are definitely cancers.

Kirklin,[9] on the other hand, using the size of the ulcer niche as a diagnostic sign in differentiating between benign and malignant ulcer, has said that in every case when the ulcer niche measures over 2.5 cm. in diameter, a malignant process should be suspected. The size of the ulcer and ulcer niche in this case, therefore, both added some real certainty to the conclusion that the nature of the lesion present was malignant.

Finally, considering the location of the ulcer brings us to a discussion of the last of the important criteria and the "raison d'être" of this paper. As has already been stated, one of the most generally accepted diagnostic criteria in differentiating between benign and malignant gastric ulcers is based upon location of the niche. It is almost a truism, if one is to believe the literature and the best medical opinion, that a niche found on the greater curvature of any part of the stomach is generally considered malignant. Only recently in 1943, Lahey,[2] in discussing a paper by Boles[2] on peptic ulcer, stated, "We agree that we have never seen a benign ulcerating lesion on the greater curvature."

In support of this great surgeon's opinion is that of a leading contemporary radiologist, Kirklin,[10] who in a personal communication, says, "I have made the statement, however, for all practical purposes, that ulcers truly on the greater curvature are malignant, realizing of course that there are rare exceptions to this rule." In support of these statements, statistics from the Mayo Clinic[2] reveal that malignancy was found in 10 per cent of lesser curvature ulcers, while 65 per cent of the prepyloric and all of the greater curvature ulcers were malignant.

Thus, all diagnostic criteria carefully considered, especially that of location on the greater curvature, the lesion in the case reported was thought to be malignant. Even at surgical exploration two surgeons could not tell definitely whether the lesion was grossly benign or malignant. Since even frozen sections were thought to be suspicious of malignancy, a partial gastric resec-

tion was carried out. Fortunately for the patient and somewhat to our surprise, the histopathological report was benign penetrating ulcer. The surgical treatment, it is felt, was the proper procedure in view of the fact that complications may arise even when a large ulcer is benign. In fact, one of these had already occurred in the form of a penetration and extension to the gastrocolic omentum and transverse colon, which necessitated an accompanying resection of these involved parts.

SUMMARY

The literature is reviewed and from this benign ulcers of the greater curvature of the stomach are found to be extremely rare. Their real incidence is unknown mainly because of lack of histological proof and inadequate follow up of the cases reported. Only 15 proved cases have been found in the literature. To this is added another case of a large gastric ulcer on the greater curvature demonstrated roentgenographically and proved by surgical resection and histopathological confirmation. The patient is alive and well, without symptoms of peptic ulcer, six months postoperatively. It is almost a truism, according to the literature and the best medical opinion of the day, that a niche located on any part of the greater curvature of the stomach should be considered malignant until proved otherwise.

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THE ROENTGEN APPEARANCE OF COMMON DUCT STONE*

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THIS report is presented to emphasize the fact that a diagnosis of common duct stone can be made by careful study of a flat roentgenogram of the abdomen or a spot roentgenogram of the bile duct area. Our conclusions are based on roentgenologic examinations in 12 proved cases of common duct stone, with special reference given to opaque stones. The demonstration of a common duct stone on a plain roentgenogram is of value to the patient and to the surgeon. If the patient is very ill it may spare him more extensive examinations. It may guide the surgeon to the site of the stone, or stones, and permit a preoperative estimate of the size of the common duct. If necessary, cholecystography, intravenous pyelography, or a gastrointestinal series may be resorted to at a later time for more definite localization of the area of calcification.

FIG. 1. Plain roentgenogram showing two common duct stones. These were diagnosed roentgenologically and were confirmed at operation.

The fact that common duct stones can be seen on the plain roentgenogram is not generally appreciated. In a brief review of the literature only one American reference to this possibility was found.† Walters and Snell, writing in 1940 on diseases of the biliary tract, do not mention this method of diagnosing common duct stone despite the fact that clinical and roentgenologic diagnosis is discussed in considerable detail. The value of the plain roentgenogram is not mentioned by Judd, Lahey, Allen, or others, writing in the past five years on the common duct stone, cholangiography and cholecystography. This omission is probably due to two factors: (1) the relative infrequency of common duct stones, and (2) the difficulty in demonstrating their location accurately.

Diagnosis of common duct stone from the plain roentgenogram is dependent upon the presence of calcification of sufficient concentration to give a positive shadow (Fig. 1). The roentgenogram should be of the best quality and preferably either stereoscopic or posteroanterior and lateral. (Even a poor quality roentgenogram will demonstrate the stone if it is very dense.) Because the common duct lies near the center of the body in the anteroposterior plane, visualization of stones in this area is more difficult than is the demonstration of gallbladder stones (Fig. 2). Gallstones, due to their proximity to the anterior abdominal wall, show more distinctly and with less distortion (Fig. 3). The rotating anode tube with its small focal spots has increased definition so that in the future common duct stones will probably be seen

† George, A. W., and Leonard, R. D. The Pathological Gall Bladder. *Ann. Roentgenol.* Vol. II, 1922. Paul B. Hoeber, New York.

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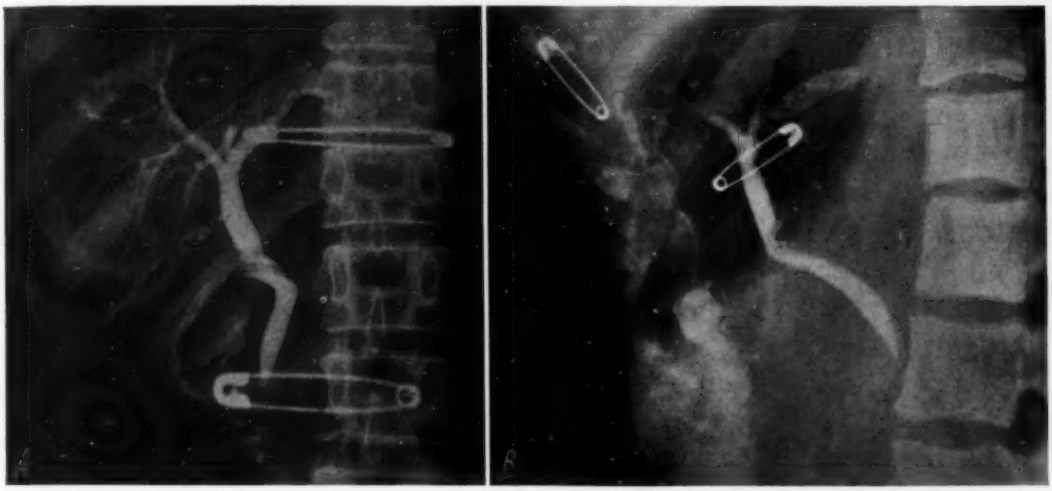

Fig. 2. Normal postoperative cholangiogram. *A*, note the relatively short common duct and the fact that it lies below the ribs; also that it crosses the upper medial pole of the right kidney and the lower end lies in the region of the renal pelvis. *B*, lateral view demonstrating the location of the common duct in the middle of the body anterior to the spine except for the extreme distal end.

with greater frequency. At the Massachusetts General Hospital we see about two cases of easily demonstrable common duct stone per year at the present time, whereas formerly this diagnosis was rare.

The chief difficulty in diagnosing common duct stones without a contrast substance lies in establishing their correct location. The differentiation of common duct stone from renal or cystic stone, therefore, is the first problem to be solved. Figure 4 illustrates the possible confusion between renal and common duct stone. The patient, prior to her admission to this hospital, had had a negative exploration performed because of an incorrect roent-

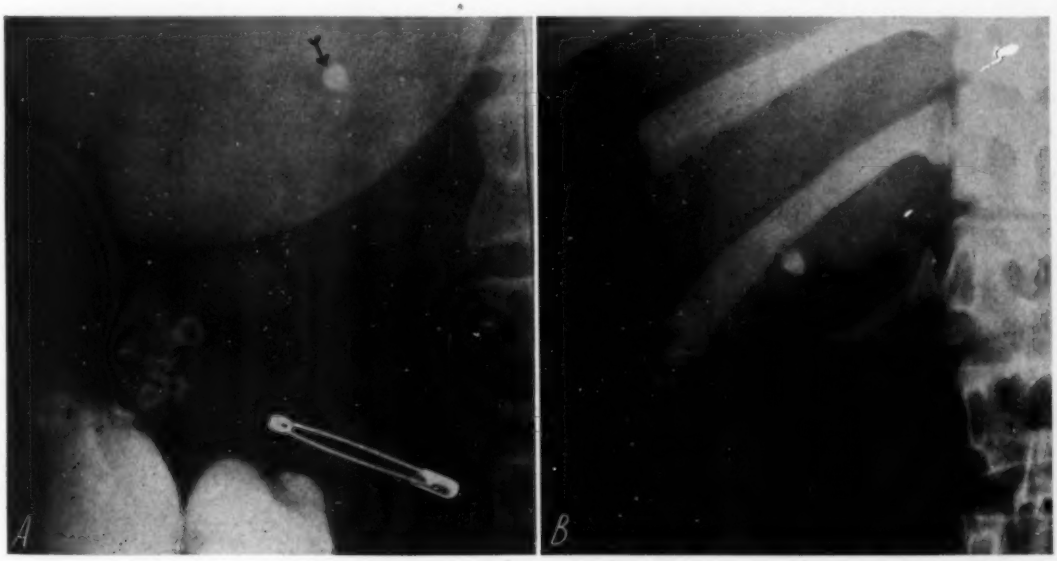

Fig. 3. *A*, a gallbladder full of stones and a stone in the common duct which was not diagnosed. *B*, postoperative roentgenogram shows stone remaining in the common duct. The patient had to be operated on again.

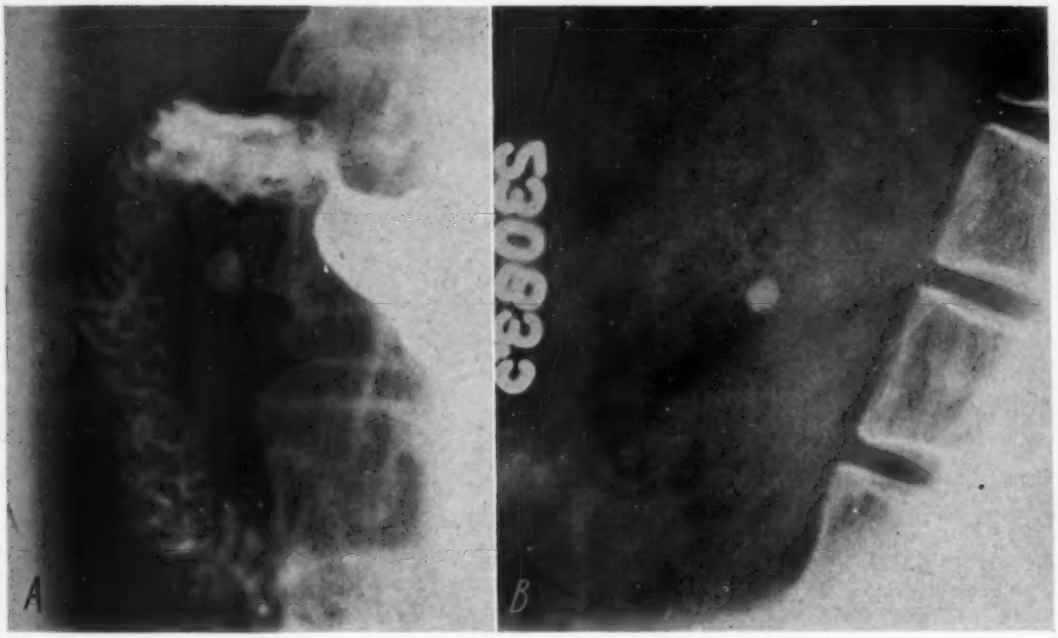

FIG. 4. *A*, the stone seems to lie in the region of the renal pelvis. A mistaken diagnosis of kidney stone was made and a negative exploratory operation had been performed. *B*, lateral view reveals that the stone is well anterior to the kidney.

genologic diagnosis of renal stone. The difficulty in this differentiation arises from the fact that in the posteroanterior and anteroposterior roentgenogram the common duct overlies the upper pole of the kidney, while the lower end of the duct usually overlies the renal pelvis. A common duct stone, however, can be well visualized on a true lateral view (Fig. 4). In this view the stone will be found to lie anterior to the spine, whereas a renal or ureteral stone will overlie the spine unless there is marked displacement of the kidney by tumor. Only if the stone lies in the ampulla will it be seen far enough posteriorly to simulate a renal stone. In obscure cases, intravenous or retrograde pyelography may be required to distinguish between these two types of calculi (Fig. 5). This procedure will eliminate the possibility of the stone being in the kidney if it is seen to lie outside the renal calices and pelvis.

FIG. 5. Intravenous pyelogram shows the location of the stone to be outside the kidney pelvis.

The decision as to whether a calculus lies in the common duct or in the cystic duct is occasionally a difficult one to make. Since a stone in the cystic duct may lead to hydrops of the gallbladder, while one in the common duct would not do so, the finding of a mass in the gallbladder region associated with calculus is indicative of a cystic duct stone (Fig. 6). The converse is not always true, however; the cystic duct stone may not necessarily cause hydrops

of the gallbladder. In some instances, examination with barium by mouth may be necessary to determine the exact location. If, in the anteroposterior projection, the stone is seen to lie in the region of the duodenum, or in the duodenal loop, the conclusion that it is in the common duct is justifiable, since it will be below the junction of the cystic and common ducts (Fig. 7). This method of examination will also

Fig. 6. A cystic duct stone with hydrops of the gallbladder. Arrows indicate the outline of the enlarged gallbladder.

demonstrate the relationship of the stone to the ampulla.

In a rare case, when the Graham test has been made in addition to the flat roentgenogram, a diseased gallbladder may be found which retains its power of concentrating dye and subsequently contracting after a fatty meal (Fig. 8). In such an instance, however, the bile ducts would probably be outlined by dye and a stone could still be accurately located. Only in a very few cases will exact localization of a stone be impossible.

Fig. 7. A common duct stone located by barium in the duodenum.

Calcium bile milk is a frequent concomitant of common duct stone (Fig. 9). In the majority of cases this roentgenologic finding will give confirmatory evidence of the diagnosis. Clinical corroboration is found in the presence of jaundice in the patient.

Fig. 8. Cholecystogram. The dye is in the gallbladder and common duct, outlining the common duct and showing definitely that the stone lies within it.

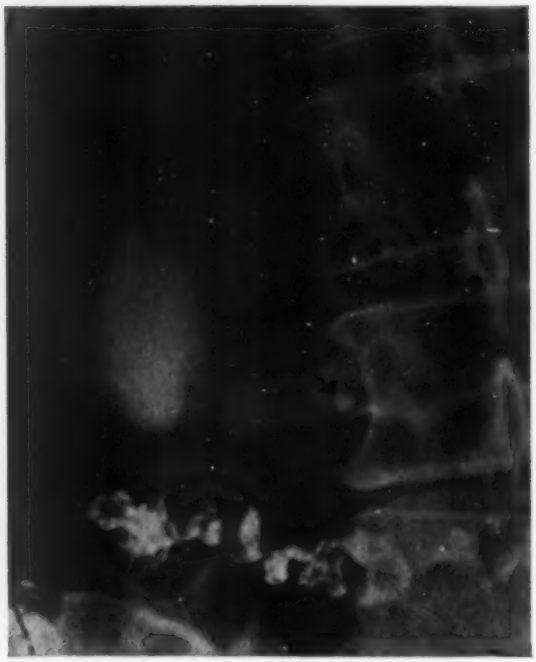

FIG. 9. Calcium bile milk in the gallbladder with a stone in the region of the common duct.

While common duct stones can, and often do, occur without jaundice being present, in many instances they lead to this clinical sign. In our experience, 4 out of 7 cases of roentgenologically and surgically proved common duct stones showed jaundice.

The differentiation of common duct stones from other areas of calcification seen on a plain roentgenogram is not as a rule difficult. Calcification of costal cartilage may be present, but it is usually above, and always anterior to, the common duct. The mistaking of an ecchinococcus cyst for a common duct stone is conceivable but unlikely. The patient's history and the roentgenologic appearance of the calculus usually establishes one or the other diagnosis. In the presence of an ecchinococcus cyst, a rounded area of calcification, generally larger than a common duct stone and lying above the common duct, is seen, with fine comma-shaped areas of calcium in the periphery.

Calcified abdominal vessels may cast a confusing cylindrical shadow, but such a shadow will be seen to change its shape with a change in the direction of the roentgen-ray beam. Absence of signs of extensive arteriosclerosis elsewhere in the patient should also rule against a diagnosis of calcification of vascular origin.

SUMMARY AND CONCLUSIONS

1. Common duct stones can often be demonstrated on plain abdominal roentgenograms or spot roentgenograms of the bile duct area. They should be suspected in any case (*a*) in which calcification is seen in the region of the gallbladder or common duct, (*b*) in which calcium bile milk is demonstrated, or (*c*) in which the patient is jaundiced.

2. In order to localize calculi accurately intravenous pyelography, cholecystography, and barium study of the upper gastrointestinal tract may be required in addition to the plain roentgenogram.

3. Certain characteristics differentiating common ducts stones are described.

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PULMONARY CHANGES IN CHRONIC CYSTIC PANCREATIC DISEASE

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THE changing concepts of disease entities attest to the dominant kinetic forces that motivate the entire field of medicine, and the roentgenologist is so oriented that he is obliged to maintain a flexibility that permits him to respond adequately to these forces. Thus, though we are all familiar with the roentgen diagnosis of bronchopneumonia and bronchiectasis in the infant, we must in the light of recent work on pancreatic disease of children modify our ways of thinking when confronted with infant chest roentgenograms.

Andersen[1,2] Blackfan and May[4] and others, have established chronic cystic fibrosis of the pancreas as a definite disease entity. In a thorough and admirable study of clinical and pathological material, Andersen described certain striking changes seen in a number of infants who succumbed to pulmonary infections. She found that the pancreas was small and irregular and that microscopically it was composed of small and large cysts lined with epithelium. The ducts were usually embedded in masses of fibrous tissue. The lungs in all cases showed bronchitis and bronchopneumonia along with many instances of bronchiectasis and atelectasis.

Clinically, the cases can arbitrarily be placed in three groups:

1. Cases of infants who succumb within the first two weeks of life. About 10 per cent of all known cases fall into this group.
2. Infants dying from bronchopneumonia or other pulmonary lesions before the age of six months. This group constitutes the largest percentage of known cases.
3. A small group who survived from six months to fourteen years and who clinically presented the so-called celiac syndrome.

Interest centers chiefly about those in the second group, for it is here that the diagnosis is most difficult and confusing. The usual history is one of a child who has frequent colds and who fails to gain weight. The child has diarrhea and foul stools at times, but with the pulmonary picture so predominant all attention is focused on the respiratory tract, so that the underlying disease process is very apt to go unrecognized.

The disease entity stands established but the relationship between the pancreatic and pulmonary lesions is as yet somewhat obscure. Andersen is of the opinion that the pancreatic changes follow obstruction of the ducts and that once the alterations in this gland are manifest, a resultant deficiency in fat absorption and metabolism ensues. This, in turn, leads to a vitamin A deficiency which results in serious epithelial changes. Rauch, Litvak and Steiner[6] do not adhere to this conception and believe that the changes are based on a coexisting congenital abnormality of the pancreas and lungs.

Even though experimental studies have failed to establish any definite relationship between vitamin A deficiencies and pulmonary epithelial lesions, the clinical and pathological evidences of a close relationship is so impressive that we cannot dismiss this hypothesis.

The disease is considered rare, but it has been aptly pointed out that it is the diagnosis rather than the condition that is rare. Undoubtedly the entity will be recognized more frequently in the future due to the able work of those who have made the basic contributions. There are no short cuts to a correct diagnosis and each case must be studied thoroughly. A low vitamin A absorption curve is a constant finding; steatorrhea is also present in all cases.

However, these changes are not diagnostic for they are known to occur in other conditions. The most reliable clinical procedure is an assay of the pancreatic enzymes, for the absence of pancreatic trypsin and lipase in the duodenal contents is absolute evidence of a pancreatic deficiency.

The prognosis is poor and thus far most of our information stems from autopsy material. This fact, however, does not justify a negative approach to this problem, for it is only when the disease process is understood and recognized early that any progress can be made therapeutically. There are some instances on record in which intensive supportive and vitamin therapy have resulted in at least temporary clinical improvement.

What rôle does the roentgenologist play in this pattern? Once the pathologic physiology of pancreatic disease is understood, we can approach the problem more intelligently and develop a critical attitude concerning bronchopneumonia in the infant. Remembering that the vitamin A deficiency leads to epithelial damage which makes the lungs readily susceptible to infection, we should expect a pulmonary process that conforms to a definite pattern and is most marked wherever there is a greater abundance of epithelium. By virtue of the distribution of the pulmonary epithelium, the infection that becomes manifest must necessarily involve all the lobes more or less equally. Acquainted with these facts, we can now anticipate the roentgen picture. The hilar regions show marked involvement characterized by areas of increased mottled densities. Towards the periphery there is streaking and mottling which is much less pronounced. The roentgen studies of the lungs in all known cases have revealed this picture consistently.

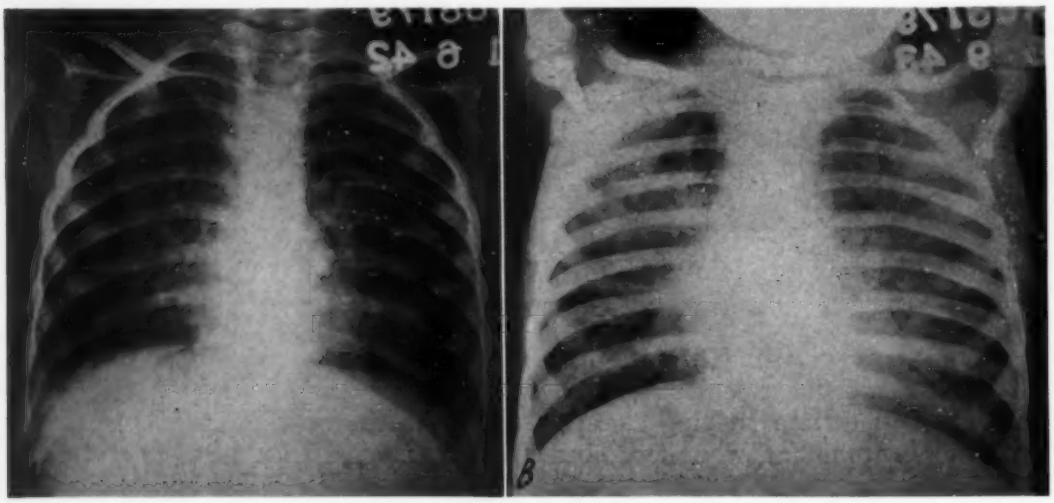

Fig. 1, *A* and *B*. Roentgenograms of the chest showing the typical distribution of the lesions and the progress of the disease over a six month period.

Since the lung alterations are set in force by an underlying pancreatic deficiency, so long as the latter exists we should expect little improvement in the lungs. All evidence bears this out and in the cases followed with roentgenograms there has been a progressive intensification of the visible lesions (Fig. 1, *A* and *B*).

Atelectasis may be expected to occur in a certain percentage of cases, for once the epithelium is damaged and infection is present, purulent exudates are apt to form and lead to bronchial obstruction. Attwood

and Sargent[3] in their presentation of 4 cases demonstrated atelectasis in the roentgenograms and also at autopsy.

Another concomitant of the serious epithelial change and infection is, of course, bronchiectasis. Andersen found that a high percentage of children with pancreatic disease did have bronchiectasis at autopsy. Attwood and Sargent[3] made the same observation. As is well known, there is but one way to establish definitely the diagnosis of bronchiectasis, and this necessitates the use of opaque medium instilled into the bronchial tree. Nevertheless, there are certain features in a chest roentgenogram which often lead one to suspect bronchiectasis. Persistent mottling at the bases, a honeycomb-like picture in the lower lung fields coupled with linear streaks that follow the bronchial pattern should put us on the alert. These features have been seen in cases of pancreatic disease and when present justify further investigation with bronchograms. Andersen has stated that any infant having bronchiectasis must be studied as a possible case of pancreatic disease (Fig. 2).

The roentgenograms recorded in several articles and those in a few cases which we are following at the present time all show a most striking similarity. The changes are those just described and they seem pertinent, though they are not diagnostic. It can be argued that similar pictures are seen in infants who have no underlying pancreatic deficiency, and such arguments are difficult to refute. Yet, unless the roentgenologist develops an understanding of this important pediatric problem, he will never appreciate the possible significance of the chest roentgenogram that is characterized by symmetrical mottling of all lobes of the lungs. The roentgen picture is so consistent that even though it cannot be considered absolutely diagnostic, when present it should certainly arouse suspicions of the possibility of fibrocystic pancreatitis. Without an awareness of the condition the roentgenologist cannot hope to stimulate the clinician. On the other hand, having developed that awareness he may well be instrumental in instituting further clinical search that will in some instances discover an otherwise unsuspected disease.

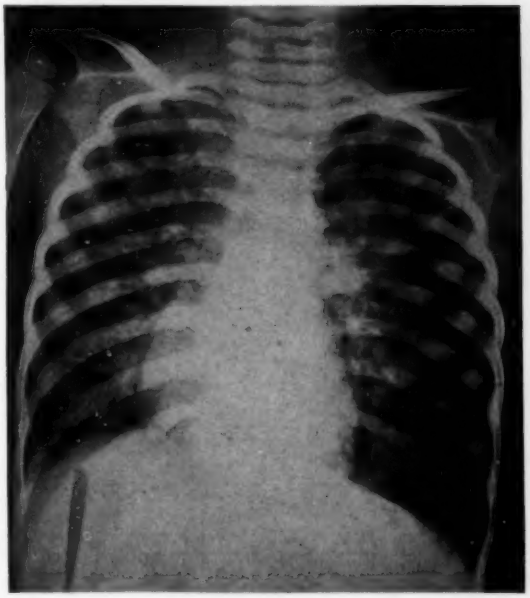

Fig. 2. Roentgenogram showing the same typical distribution of the lesions with the predominant changes in the inner third of the lungs.

Another roentgen aspect of cystic fibrosis of the pancreas concerns the secondary changes in the intestinal tract physiology. Flax and his coworkers[5] have demonstrated hypomotility associated with some dilatation of the small intestine. Occasionally these changes are manifest even without barium studies, for the plain roentgenograms may show fluid levels in segments of the small intestine. These findings are in no way pathognomonic, but when seen in conjunction with the described pulmonary picture, they are of such significance as to make further clinical studies mandatory.

I do not wish to convey the opinion that the roentgenologist can arrive at the diagnosis of chronic cystic pancreatitis without equivocation. I do, however, believe that if he is acquainted with this disease entity he will frequently be of distinct aid to the clinician. If the proper diagnosis can be

made early enough vigorous therapeutic measures may lead to clinical improvement.

It is fair to state that the pediatrician has acquainted himself with this problem and that frequently he will be the one who first suspects the diagnosis. Frankly, this has been true in the small number of cases studied thus far at the Duke Hospital. This very fact being true is all the more reason that the roentgenologist be conscious of the problem, lest he be found wanting in his cepacity as a consultant.

In conclusion, any infant who shows the lung changes discussed and who fails to improve under the usual modes of therapy should be suspected of having chronic cystic pancreatitis and investigated intensively with this in mind. Then, and only then, will it be possible to make any progress in the eventual solution of this intriguing problem.

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THE ROENTGEN DIAGNOSIS OF PANCREATIC DISEASE*

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INASMUCH as we have been able to examine roentgenographically a large variety of cases of pancreatic disease, which were studied also pathologically, we find it possible to review critically and to illustrate the criteria for the roentgen interpretation of diseases of the pancreas.

The roentgen study of the pancreas is difficult because the specific density of this viscus is the same as that of its surrounding tissues, so that it cannot be visualized directly. Furthermore, it is one of the few viscera in the abdomen which cannot be outlined by a radiopaque substance. Its duct system has been visualized in occasional cases by reflux during cholangiography and by retrograde filling during duodenoscopy. Engel and Lysholm have inflated the stomach with carbon dioxide, partially visualizing the contiguous anterior border of the pancreas. The pancreas has been also visualized incompletely after the induction of artificial pneumoperitoneum and the retroperitoneal injection of air or oxygen using a modified Carelli technique.

These methods are not easy of application and are not without risk or ill effects. It has therefore been necessary, for ordinary routine purposes, to continue with simple indirect methods which demonstrate chiefly mechanical effects upon the contiguous structures, notably the barium- or gas-filled stomach, duodenum and colon. For translation of the roentgen data into terms of pathologic anatomy, an understanding of the gross anatomy of the area is essential.

ANATOMY

The pancreas is a long retroperitoneal gland lying rather transversely in the posterior portion of the upper half of the abdomen. The greater part of the organ lies behind the stomach. It is 12 to 15 cm. in length, and consists of a head, neck, body and tail.

The head is flattened and lies within the duodenal curve to the right of the midline, and is related anteriorly to the mid-transverse colon and posteriorly to the abdominal aorta. Its right and inferior borders are molded on to the side of the duodenum, which lies in a groove of the gland substance—the bile duct being interposed as far down as the middle or lower third of the descending duodenum. The uncinate process of the head is that portion which extends towards the left along the third part of the duodenum and is posterior to the superior mesenteric vessels after passing forward through the pancreatic notch.

The neck is about 2.5 cm. in length and is directed first upward and forward and then upward and to the left to join the body. It is related anterosuperiorly to the pylorus. In front and to its right lies the first part of the duodenum. In the upper border of the neck there is a process of glandular substance, the tuber omentale, which generally projects above the lesser curvature of the stomach.

The body is related anteriorly to the stomach. Posteriorly it is in contact with the left kidney and left suprarenal gland.

There are several pancreatic variations: (1) a separation of a part of the head, known as the uncinate process, which then forms a lesser pancreas; (2) a growth of the pancreas around the duodenum which it may practically encircle (annular pancreas), with or without obstruction; (3) an accessory pancreas in the stomach, duodenal or jejunal wall; (4) pancreatic tissue in a Meckel's diverticulum; and (5) ectopic position of the pancreas, as for example, in a diaphragmatic hernia.

The terminal arrangements of the common bile duct and the main and accessory

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pancreatic ducts show several variations. Mehnen, through autopsy of 449 cases, found that the common bile duct and the main pancreatic duct joined above a common sphincter in 61 per cent of his cases. His second most common finding was for each duct to open separately into the duodenum. The third variation was for the duct of Santorini (accessory pancreatic duct) to be the principal pancreatic excretory passage, opening independently into the duodenum.

According to Giordano and Mann, about two-thirds of their subjects showed union of the common and main pancreatic ducts before entering the duodenum and about one-third had separate openings into the duodenum.

The common ducts showed a variation in its relation to the duodenum. There are three main variations, which are numbered, in their order of frequency, on the illustration (Fig. 1).

PATHOLOGIC CHANGES

To better understand the roentgen features, lesions of the pancreas may be divided arbitrarily into four groups:

Group 1. Lesions within the pancreas which are demonstrable on a simple roentgenogram.

Group 2. Lesions which may produce effects on contiguous structures.

Group 3. Lesions which produce their effects on structures not intimately related to the pancreas.

Group 4. Lesions which are too small to provide any roentgen manifestations.

Group 1. This consists of lesions which are directly demonstrable within the pancreas. Of these, the most common are calculi, which are most likely caused by inspissation of bile in the pancreatic ducts. They are usually multiple and consist of calcium phosphate, calcium carbonate, cholesterin or organic substances. Very rarely infarcts may calcify. Cysts of the pancreas and fat necrosis may calcify subsequently, becoming indistinguishable roentgenographically from ordinary calculi.

Opaque foreign bodies such as bullets, shrapnel, knife fragments or chicken bones which have perforated into the duodenum have been reported.

Gas abscess with a demonstrable fluid level has also been described.

Occasionally a pancreatic tumor is so dense that it is directly demonstrable on the simple roentgenogram of the abdomen.

Group 2. This comprises the lesions which may produce effects in contiguous structures demonstrable roentgenographically. The most important are tumors, of which carcinoma is the most common. It may be difficult occasionally to determine histopathologically whether one is dealing with a primary or a metastatic lesion of the pancreas (Henke and Lubarsch). As to the location of carcinoma, Ewing states that in a series of 386 cases 158 were diffuse, 156 in the head and 28 in the body. He does not mention any occurring in the tail. However, other authors report an incidence of about 1 per cent in the latter location.

Carcinoma of the pancreas is more common in males, 69 per cent, than in females, 31 per cent. It is a disease primarily of middle age, most frequently occurring between the ages of forty and seventy.

Ewing divides carcinoma of the pancreas into groups: (1) Cylindrical cell adenocarcinoma, arising from the ducts, a type which at times produces a massive tumor, and is most frequent in the head, occasionally containing cysts; and (2) carcinoma simplex, a type which is more diffuse, arises from the parenchyma, has considerable desmoplastic properties, and rarely becomes massive.

Metastatic lesions to the pancreas occur with about the same frequency as primary carcinomas. They may be massive and cause considerable enlargement. Practically any tumor may metastasize to the pancreas, but the most common metastases arise in the gastrointestinal tract.

Cysts often reach sufficient size to be demonstrated roentgenographically. Retention cysts, inflammatory cysts, pseudocysts, cystadenomas and congenital cysts have been described. Their individual incidence varies with different authors. Many

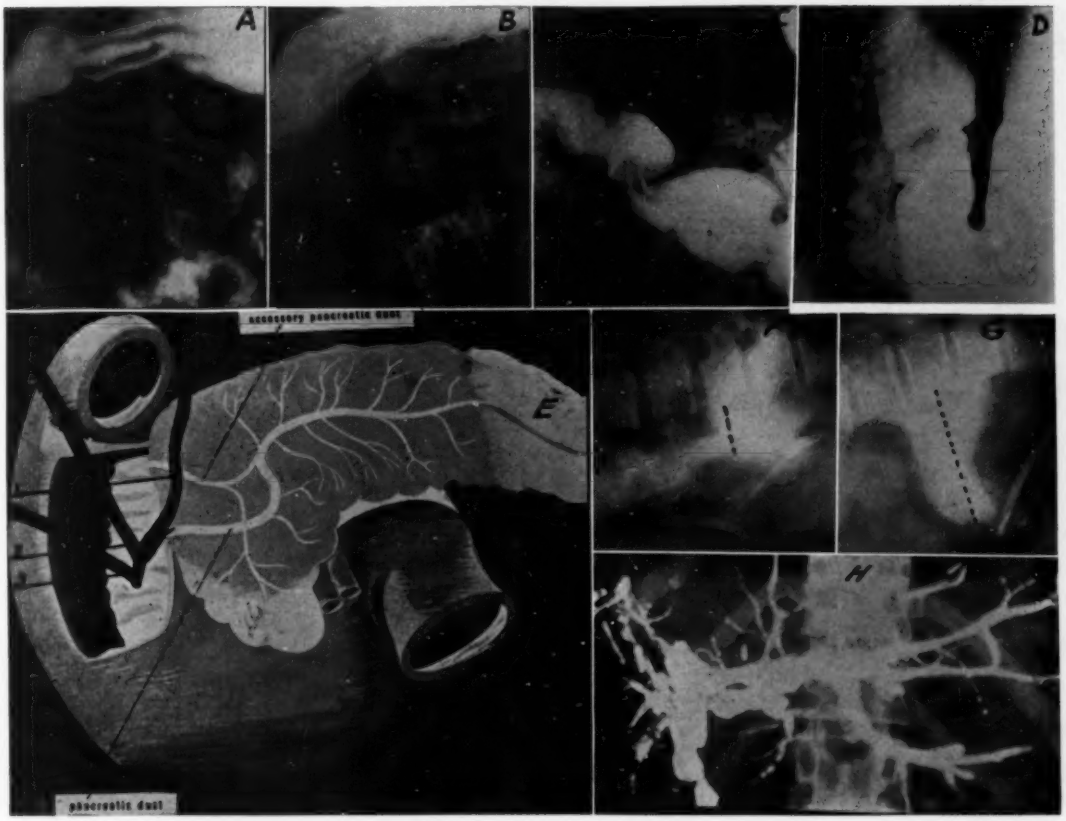

Fig. 1. *A*, *B*, *C* and *D*, normal appearance of the barium-filled duodenal loop in the various forms of habitus: *A*, marked hypersthenic; *B*, moderate hypersthenic; *C*, sthenic; *D*, hyposthenic.

E, diagram showing three main positional variations of the common duct, numbered in the order of frequency. *F*, example of the use of the Engel and Lysholm method in the normal. *G*, the same method in cancer of the head and body, showing widening of the retrogastric soft tissues. *H*, visualization of pancreatic duct system by reflux during cholangiography in a case of common duct obstruction near the ampulla, due to non-opaque calculi.

authors state that psueudocysts are most common because of the absence of a true epithelial lining. Others consider, however, that an epithelial lining will be found somewhere in the cyst if numerous sections are made, and that the most common group, therefore, is the cystadenoma (Otani). These may be benign or malignant. They are found most commonly in the body and tail and become extremely large. At times they occupy the entire abdominal cavity and are difficult to differentiate from ovarian or omental cysts.

Inflammatory cysts occur very frequently in the South American countries and are usually due to parasites. Nematodes, taeniae and echinococci have been found in such cysts.

Sarcoma of the pancreas is very uncommon. Those reported were usually lymphosarcoma.

Amyloidosis may occasionally affect the pancreas, causing considerable enlargement.

Annular pancreas is a congenital anomaly, in which the pancreas completely encircles some portion of the duodenum, causing a variable amount of obstruction. There are no definite pathologic findings in the pancreatic tissue, but occasionally one finds considerable atrophy and shrinkage in the portion which surrounds the duodenum.

Aberrant pancreatic tissue has been found distributed over many different portions of the gastrointestinal tract. On occasion it has been reported in the second

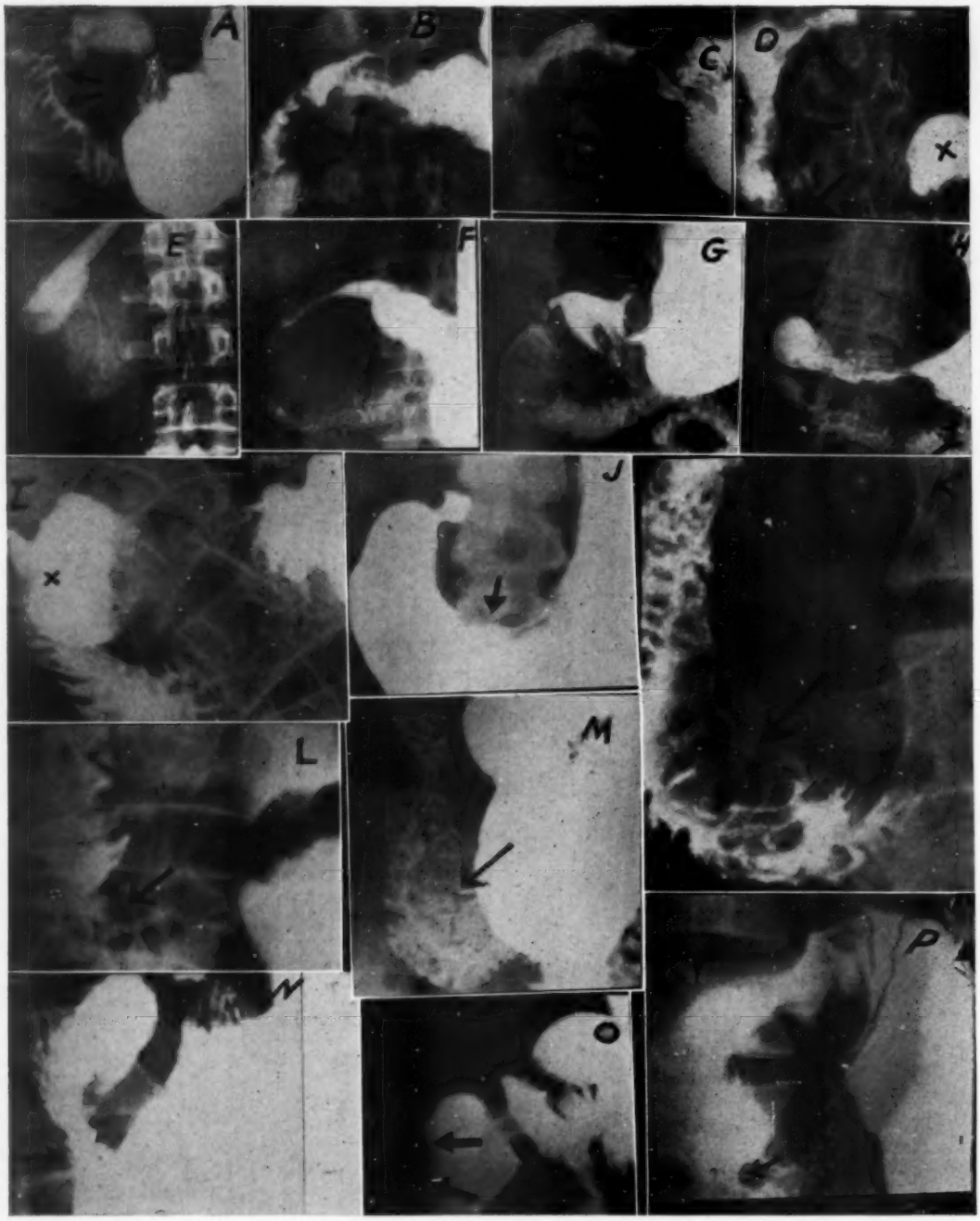

FIG. 2. *A*, carcinoma of the pancreatic head 1½ inches in diameter. *B*, Changes similar to *A*, due to metastatic nodes from a gastric carcinoma. *C*, carcinoma of the pancreatic head 2½ inches in diameter. *D*, carcinoma of the pancreatic head 4 inches in diameter—note diverticulum of ascending duodenum marked *x*. *E*, extrarenal soft tissue mass in the right upper quadrant seen during pyelography. *F*, same as *E*, which shows mass to be within duodenal loop, and was later found to be carcinoma of the pancreatic head. *G*, intussusception of stomach far into the duodenum, widening it. *H*, same case after the intussusception is reduced. *I*, carcinoma of the head of the pancreas with perforation into the duodenum—perforation pocket is marked *x*. *J*, indentation of the lesser curvature of the stomach due to carcinoma of the pancreatic head, in a very hyposthenic individual. *K*, deformity of the duocenum due to an infiltrating carcinoma of the pancreatic head. *L* and *M*, small localized defect due to carcinoma of the ampulla. *N*, pressure defect on the

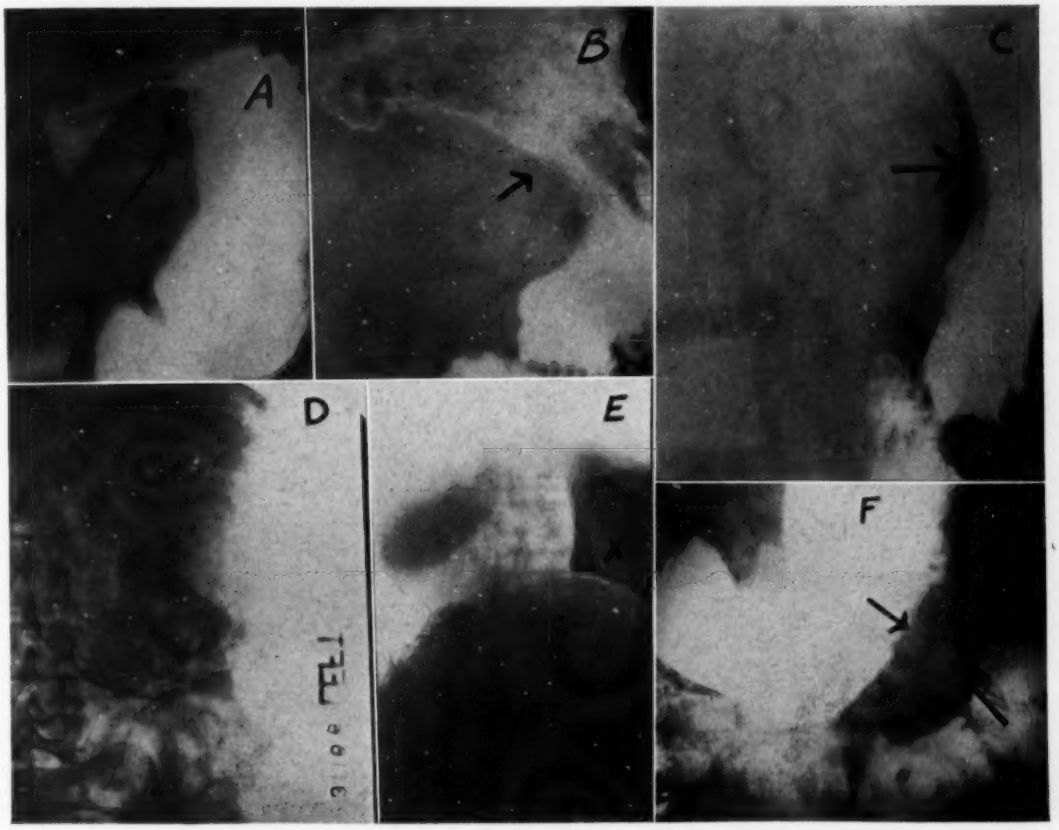

Fig. 3. *A*, carcinoma of the pancreatic tail. *B*, benign cyst in the pancreatic tail, measuring 2½ inches in diameter. *C*, carcinoma of the body and tail, causing a forward displacement of the stomach which has previously been partially resected; a few pancreatic calculi are seen. *D*, large calcified pancreatic cyst arising in the tail. *E*, same as *D*, showing marked indentation of the stomach—marked *x*. *F*, small irregular calcifications in a pancreatic cyst of the tail after marsupialization.

portion of the duodenum, causing a filling defect.

Among the specific infections, mumps occasionally causes an inflammation of the pancreas with considerable enlargement. Tuberculosis is very uncommon in the pancreas. Syphilis typically causes marked shrinkage, but occasionally it produces small nodules throughout the head and body, although on rare occasions large masses have been described. Rarely large gummas of the pancreas have been reported.

Group 3. Meconium ileus is a condition in which meconium becomes inspissated in the gastrointestinal tract and acts as a plug, producing intestinal obstruction. It is believed to be due to congenital stenosis of the opening of the pancreatic duct. This is followed by dilatation of the duct system with atrophy and fibrosis of the parenchyma leading to cystic fibrosis of the pancreas. Lack of pancreatic juice results in a failure to digest the fats and proteins in the meconium, which is the most likely reason for the inspissation. There may be an asso-

outer convex border of the descending duodenum due to a posterolaterally placed dilated common duct secondary to carcinoma of the ampulla. *O*, extrinsic pressure defect on the descending duodenum due to enlarged gallbladder, in a case of carcinoma of the ampulla, in which the common duct was normally placed. *P*, carcinoma of the head of the pancreas in an annular pancreas, which causes stenosis of the duodenum near the junction of the descending and inferior horizontal portions.

ciated pulmonary fibrosis. In cystic fibrosis of the pancreas a sprue-like small bowel pattern is found.

In acute hemorrhagic pancreatitis the pancreas may become markedly swollen, soft, boggy, and produce effects on adjacent structures. In addition, because of the seepage of some of the pancreatic ferments into the peritoneal cavity, irritation of the psoas muscle and alteration of diaphragmatic movements can be demonstrated with abnormality in gastrointestinal function.

Fat necrosis may occasionally cause peritonitis.

Group 4. These lesions are merely mentioned for the sake of completeness. They do not cause any change within the pancreas that could be demonstrated roentgenographically.

(a) Diabetes mellitus.

(b) Hemochromatosis.

(c) Chronic pancreatitis without demonstrable calcification. Occasionally it has been reported that this lesion may cause pressure defects on contiguous structures. However, this seems unlikely when one considers the pathological changes, which consist of atrophy, shrinkage, and considerable

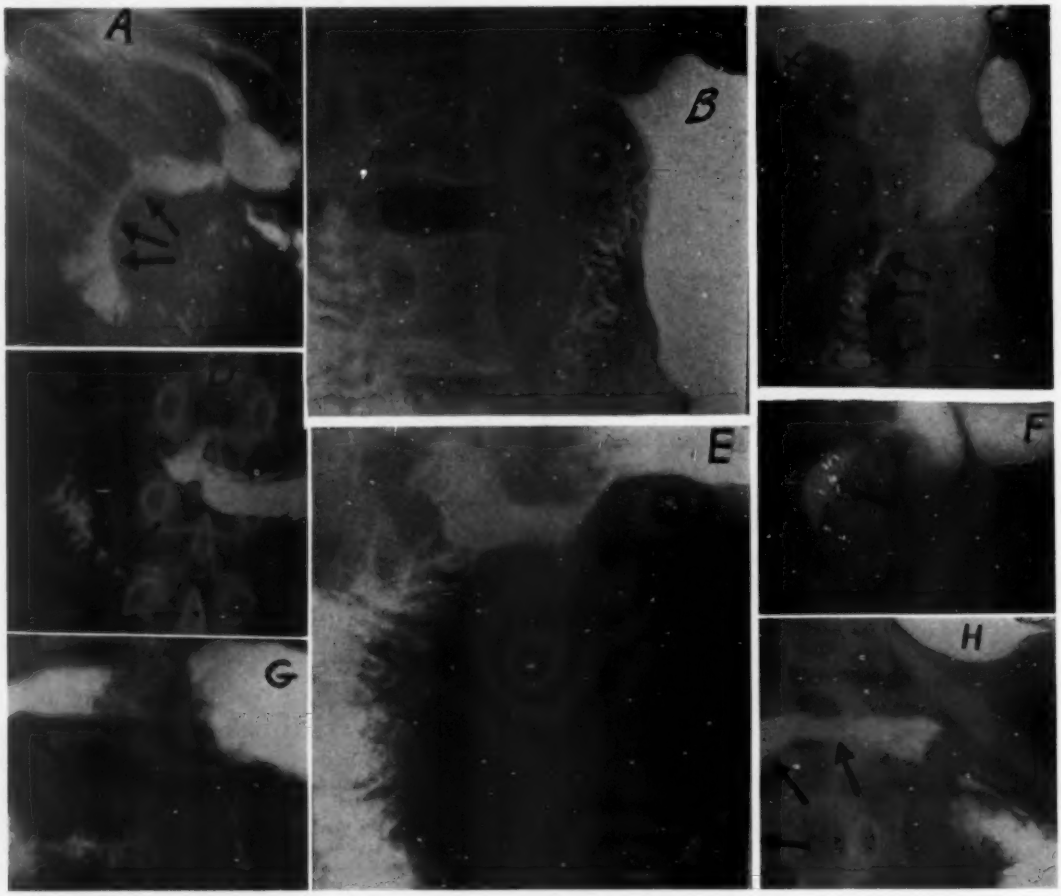

FIG. 4. Deformities of the inner concave border of the descending duodenum produced by: *A*, metastatic nodes from a neuroblastoma of the left suprarenal gland—right lateral view; *B*, enlarged tuberculous nodes; *C*, upward traction of the duodenum about the pancreatic head by a stomach herniated up through the diaphragm—note the ulcer on the lesser curvature of the pars media of the herniated stomach—marked *x*; *D*, enlarged lymph nodes in a case of proved infectious mononucleosis. The enlarged nodes were absent on re-examination four weeks later and again in five months; *E*, retroperitoneal follicular lymphoblastoma; *F*, simple cyst of the head of the pancreas; *G*, carcinoma of the mid-portion of the common duct; *H*, amyloidosis.

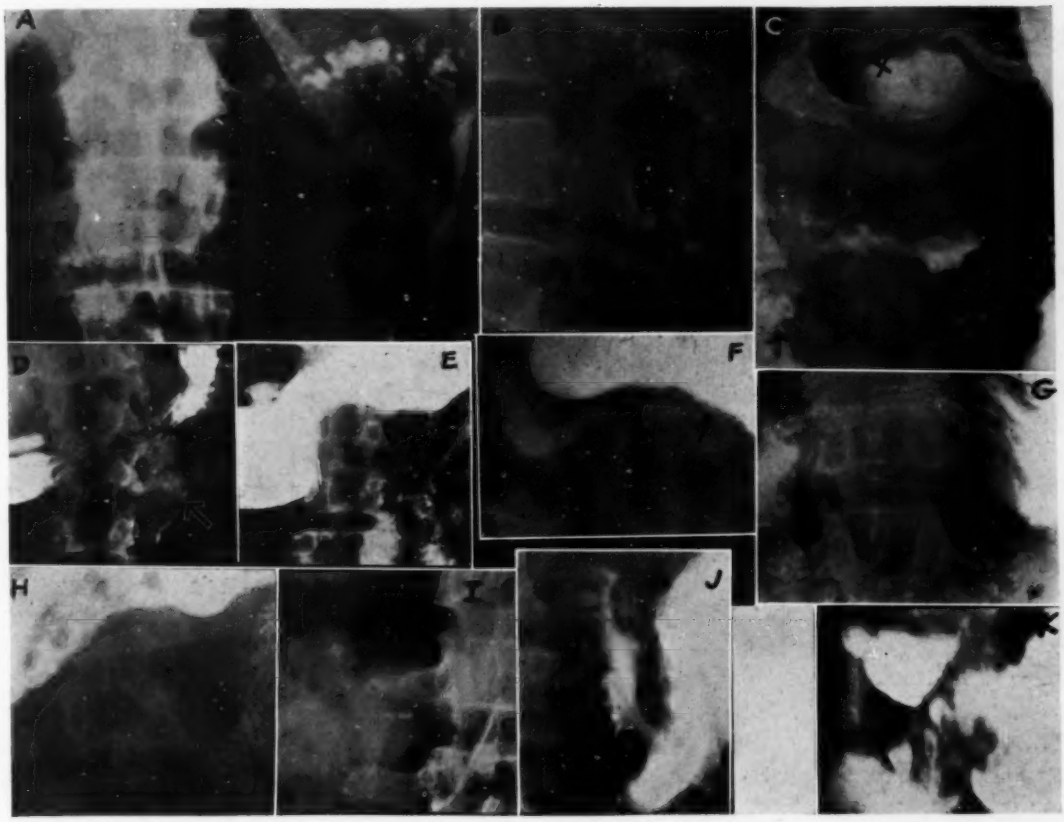

Fig. 5. *A*, pancreatic calculi, posteroanterior view. *B*, same case, lateral view. *C*, enlarged duodenal loop due to pancreatitis—note several calculi near arrow in common duct. Incidentally, note large diverticulum arising from the posterior wall of the cardiac end of the stomach—marked *x*. *D*, aneurysm of the abdominal aorta with small amount of barium in the stomach. *E*, same case with larger amount of barium in the stomach, showing defect on greater curvature. *F*, defect on greater curvature of the pylorus, which was due to a melanocarcinoma secondary to a similar lesion in an eye previously removed. *G*, carcinoma of head and body 2½ inches in diameter. *H*, cyst of the greater omentum, just below the stomach. *I*, several small calculi in the terminal portion of the main pancreatic duct. *J*, carcinoma of the body indenting the stomach. *K*, carcinoma of the pylorus with perforation into the pancreas—note the extraluminal barium.

connective tissue replacement of the parenchyma. Hence, when a chronic pancreatitis exists with enlargement, an associated carcinoma should be considered.

(d) Small retention cysts, small cystadenomas, tumors of the islands of Langerhans, and idiopathic hypoplasia.

ROENTGEN MANIFESTATIONS

Except for functional changes, which are now used more for their suggestive value, direct roentgen signs (such as obvious dense masses seen on the simple roentgenogram, calcifications, opaque foreign bodies, or collections of gas with fluid levels in the upright or lateral recumbent postures), the roentgenologic criteria of pancreatic disease depend almost entirely upon the presence of a pressure defect. They simply signify pressure from enlargement of the normal regional structures or pressure from the formation of adventitious space-occupying masses. The manifestations are therefore not pathognomonic for any single lesion.

The larger the mass and the nearer it is to the contrast-filled stomach or bowel, the easier will be its detection. A small mass contiguous to the contrast-filled stomach or bowel may be detected earlier than a large mass more removed, because of its early

indenture or invasion of these structures. The corollary also is obvious, i.e., that disease in and around the pancreas which does not enlarge the pancreas or the regional lymph nodes is impossible of detection roentgenographically because of the absence of a mechanical pressure defect.

With few exceptions it has become our practice to report simply that there is evidence of "an abnormal mass in the region of the pancreas," avoiding a specific statement of its nature. Some cases may present characteristic clinical or laboratory findings which will permit a precise diagnosis.

For these reasons the roentgen findings will be discussed on the basis of the anatomical location of the lesions, and fall therefore into two groups: (1) Lesions in the head of the pancreas. (2) Lesions in the body or tail of the pancreas.

Group 1. The following signs point to the presence of a mass in the region of the head of the pancreas:

(a) Enlargement or spreading out fanwise of the duodenal loop or widening of the semicircular arc described by the duodenum. It is important in evaluating this sign to exclude apparent enlargement due to a hypersthenic habitus in which the stomach is high and almost horizontal in position and the duodenal loop is fully exposed and therefore appears to be enlarged. Apparent enlargement alone consequently is less significant in the hypersthenic. In these individuals it is mandatory to demonstrate, in addition, some evidence of extrinsic pressure on the inner concave border of the descending duodenum or on the greater curvature side of the duodenal bulb or pylorus. The extrinsic pressure, by its rounding or ironing-out effect, changes the direction of the mesial ends of the duodenal mucosal folds (valvulae conniventes). With severe pressure the pattern of the valvulae conniventes may be greatly altered or even lost. The extrinsic pressure defect may be localized above or below the ampullary region or may be general and include the entire inner concave border of the descending duodenum, either as one smooth, rounded-out contour or as multiple scallop-shaped defects. The large, smooth, rounded defects are more likely to be due to cysts.

(b) Displacement of the duodenal loop towards the right and anteriorly by space-occupying masses in the region of the pancreatic head. The displacement may be either general and uniform or simply a localized indentation on the lower concave border. The stomach may be displaced upward and foward if the lesion is large.

(c) Fixation of the duodenal loop, especially its medial wall. This may impair the normal expansion.

(d) Diminished caliber of the duodenal lumen, causing obstruction and delay in the emptying of the stomach.

(e) Irregularity of the contour of the inner concave border of the descending duodenum, with or without alteration or destruction of the mucosal pattern. The cases causing destructive changes are most apt to be carcinomatous.

(f) Alteration of duodenal peristalsis. This may be diminished, absent, or antiperistalsis may occur.

(g) Palpable mass.

(h) Downward and forward displacement of the transverse colon.

(i) An extrinsic pressure defect on the outer wall of the descending duodenum, in cases of common duct obstruction. It was our impression previously that this was due to a distended gallbladder. However, in a pathological study we found that it may also be due to a distended, unusually placed common duct. As described and illustrated in the section on *Anatomy*, the common duct may enter the papilla of Vater in many ways. When the common duct becomes greatly dilated in Position III it will press the duodenum forward and medially. When the common duct is in Position I it will not produce this effect. Various intermediate degrees of indenture may result, depending upon the entrance point of the papilla of Vater. An attempt was made at postmortem to inject the common duct to see whether this defect could be reproduced, but the resiliency of the duct prevented a satisfactory study. Speci-

mens removed at operation en masse, however, substantiated our assumption. This finding, therefore, in a patient with a painless increasing jaundice, in whom no abnormality is found on the inner concave wall of the duodenal loop, suggests an obstruction at the ampulla or in the lower portion of the common duct.

(j) Kirklin has described a case with a central filling defect in the duodenal bulb which had the appearance of an intrinsic polypoidal lesion. This, however, was caused by a pancreatic nodule impinging on the lumen of the duodenum from behind.

(k) After cholangiography in the presence of a mass in the pancreatic head there is no filling of the lower portion of the common duct, which is usually cut off abruptly and often in a transverse diameter rather than a tapering or funnel-shaped pattern. The patent proximal portion of the common duct and the cystic duct are widened.

(l) Case described the following signs which he has found of particular use in the diagnosis of acute inflammations of the pancreas: Elevation of the stomach, transverse position of the duodenal bulb with or without enlargement of the duodenal loop, collection and stasis of appreciable quantities of contrast material in the dependent portions of the duodenum, fullness between the stomach and transverse colon, limitation of excursion of the left diaphragm, formation of pleural exudates, ill-defined left psoas contour, pressure indentations on the stomach and duodenum, coarsely feathered duodenal mucosal relief, abnormal gas distention of the colon, and even a paralytic ileus with the formation of fluid levels when the patient is examined in the erect or lateral recumbent postures.

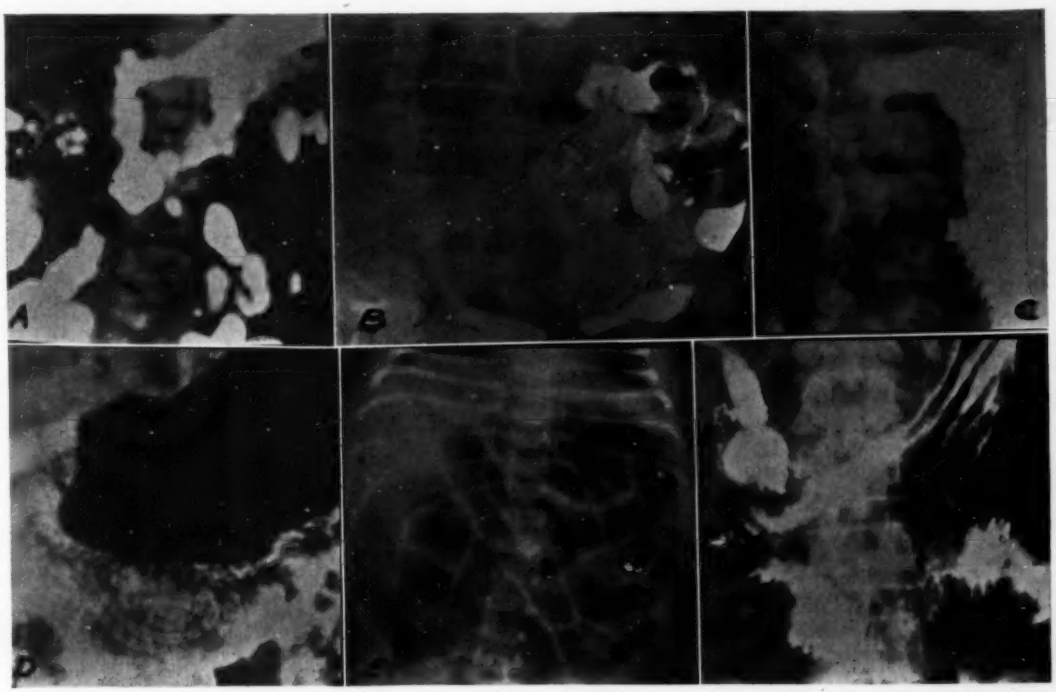

Fig. 6. *A*, small bowel "deficiency pattern"—child with known pancreatic deficiency. *B*, similar pattern in an adult with known pancreatic deficiency. *C*, irritability of the duodenum in a case of parotid mumps with abdominal tenderness. This perhaps tends to indicate involvement of the pancreas by a similar lesion. *D*, round worm in the duodenum—note barium in the intestinal tract of the worm. *E*, meconium ileus. *F*, small bowel pattern after a Whipple operation for carcinoma of the pancreatic head.

Group 2. The following signs point to the presence of a mass in the region of the body or tail of the pancreas:

(a) The stomach is displaced and indented in a forward, upward or downward direction, producing a varying degree of compression, with or without obstruction. The type of roentgen manifestation is greatly influenced by the habitus and exact location and size of the abnormal mass. A mass in the region of the pancreatic body may cause an indenture on the lesser curvature of the stomach in a hyposthenic individual, while a similar appearing mass is more apt to produce an indenture on the greater curvature of the stomach in a hypersthenic individual. It is therefore evident that the fundamental disposition and variance of the viscera and their interrelationship, as determined by body habitus, influence to a great degree the roentgenological manifestations of a mass in the region of the pancreatic body or tail and should always be borne in mind when the cause for the abnormality is considered.

(b) The mid-transverse colon is displaced forward and downward.

(c) The ascending duodenum and the duodenojejunal flexure are displaced and indented in a forward, downward or upward direction, producing a varying degree of compression and obstruction. The duodenum proximal to the indented area may be dilated.

DIFFERENTIAL DIAGNOSIS

Lymphosarcoma, leukemia, Hodgkin's disease, metastatic tumors, tuberculosis, giant follicular lymphoblastoma, and infectious mononucleosis may cause considerable enlargement of the regional lymph nodes, producing roentgen signs which are indistinguishable from those caused by intrapancreatic masses of similar size.

Aneurysms arising from the anterior wall of the upper portion of the abdominal aorta may extend forward and simulate a pancreatic mass. These aneurysms may show linear or curvilinear calcifications.

Omental cysts, calcified or not, may be found along the lesser or greater curvature of the stomach, causing extrinsic pressure defects which are indistinguishable from intrapancreatic masses.

Diaphragmatic hernia of the stomach may cause upward traction upon the duodenal loop with pressure on the inner concave border. If the hernia is marked the pancreas may be in an ectopic position.

Intussusception of the stomach into the duodenum can deform the latter so that a pancreatic mass may be simulated.

Exogastric lesions (extramucosal) such as myosarcoma, leiomyoma and metastatic tumors in the stomach wall may cause masses which resemble pancreatic masses and cannot be differentiated.

Carcinoma of the papilla of Vater or of the lower portion of the common bile duct clinically may simulate a mass in the pancreatic head. In the latter, roentgenographically there is usually found enlargement, displacement or encroachment upon the duodenal loop.

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ROENTGENOLOGIC OBSERVATIONS IN MESENTERIC THROMBOSIS*

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THE authors as roentgenologists wish to describe their observations of the roentgen examinations in 3 proved cases of superior mesenteric thrombosis. Briefly, there was one common and striking finding in the plain roentgenogram of the abdomen in these cases which we believe has some diagnostic merit: namely, distention of small bowel and the right half of the colon, simulating the criteria of a mechanical obstruction. The gas collection ended abruptly at the left end of the transverse colon. The distended bowel corresponded to the distribution of the superior mesenteric vessels. In 1 case, a barium enema was given and, to our surprise, no mechanical lesion was found although expected by the sharply demarcated distention down to the splenic flexure as noted in the flat roentgenogram of the abdomen. This observation suggests the possible value of a sign-complex in the diagnosis of superior mesenteric occlusion: the free passage of the barium through a section of intestine so distended as to otherwise suggest a mechanical obstruction.

Historically, the clinical entity of mesenteric thrombosis has been known for over one hundred years. Statistics show that the mortality is high and the preoperative diagnosis rare. Due to simulation of other abdominal disease, notably intestinal obstruction, it is difficult to recognize in its earlier stages "when surgery should offer a very excellent prognosis," as Donaldson and Stout[3] believe. Observers have reported that complete gangrene of the bowel with bloody ascites did not occur until eighteen hours after the onset of symptoms. Examination of the literature reveals that roentgenologic examination of the abdomen in this disease is very infrequent.[2] Douglas[4] describes a case in which "the location and extent of the lesion was demonstrable by the plain film of the abdomen." He observes that of 92 cases reviewed by Myers in 1931 in none was a plain roentgenogram of the abdomen taken to determine the presence of gas. In a survey of the literature by Bowen and Felger[2] in January, 1942, no mention is made of roentgen examination in the cases reported. In 1940 Berman and Thornton[1] described a case in which a roentgenogram taken the day before operation showed "marked distention of the small intestine." But how common is intestinal distention in mesenteric thrombosis, if roentgen study is to be of any value? The literature tells us that distention as a symptom in this disease was present clinically in 48.3 per cent in the Mayo Clinic series, in 65 per cent of cases reported by Cokkinis, in 78 per cent by Jackson, Porter and Quimby, and in 27 of 36 cases reported by Blackburn. In 9 cases in which laparotomy was done, Loop found the intestinal lumen to be "extremely relaxed." Bowen and Felger state: "With infarction, the intestine becomes purple-black in color, loses its elasticity and lustre, then progresses to the final stage of gangrene and peritonitis."

The pathogenesis of this disease has been well described by many authors. The general causes of mesenteric thrombosis have been classified as cardiovascular, infectious, mechanical and traumatic.[5] It is reported that the average incidence of occlusion of the mesenteric arteries is only slightly greater than venous occlusion. Occlusion of the superior mesenteric artery is said to be forty times more frequent than block of the inferior mesenteric artery.

Following are the roentgen findings and case reports of 3 patients who had mesen-

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FIG. 1. Case 1. Distention of the small intestine and the proximal half of the colon. The sharp demarcation of the gas column suggests a mechanical block near the splenic flexure. The distended intestine corresponds to the distribution of the superior mesenteric vessels.

teric thrombosis. One patient died before surgical intervention and the other 2 cases made normal recoveries after resection of gangrenous bowel.

CASE REPORTS

CASE 1. A preoperative diagnosis of mechanical obstruction was made on the plain roentgenogram of the abdomen because of considerable distention of the small bowel and the right half of the colon. The gas column ended abruptly at the left end of the transverse colon. The distal part of the colon was empty of gas. The sharp demarcation of the distended gut suggested a mechanical block, and a barium clysma was given for confirmation. To our great surprise, the opaque mixture passed readily through descending, transverse and ascending portions of the colon. Two changing areas of spasm were noted in the sigmoid, probably reflex from peritoneal irritation. The patient's general condition was considered unsatisfactory for operation and death occurred the next day. Autopsy revealed a thrombus in the superior mesenteric artery, with gangrene of the entire small bowel and the right half of the colon. The purplish gangrenous gut tapered off gradually to a normal appearance as the mid-transverse colon was approached.

F.B., Russian Hebrew, female, aged seventy-five years. The patient was admitted to Kings County Hospital, Brooklyn, New York, in October, 1942, with complaints of obstipation and abdominal pain, for a duration of two and one-half days. The clinical diagnosis on admission was intestinal obstruction. Frequent vomiting, not fecal in content, had persisted since the onset. No bowel movements after cathartics and enemas. Abdominal distention marked in the last twenty-four hours.

The past history disclosed an old hernia, with the use of a truss. Also indefinite weight loss in the last six months. Recently the patient had been taking one tablet of digitalis daily, with a story of ankle edema and hypertension.

Physical examination showed an aged white

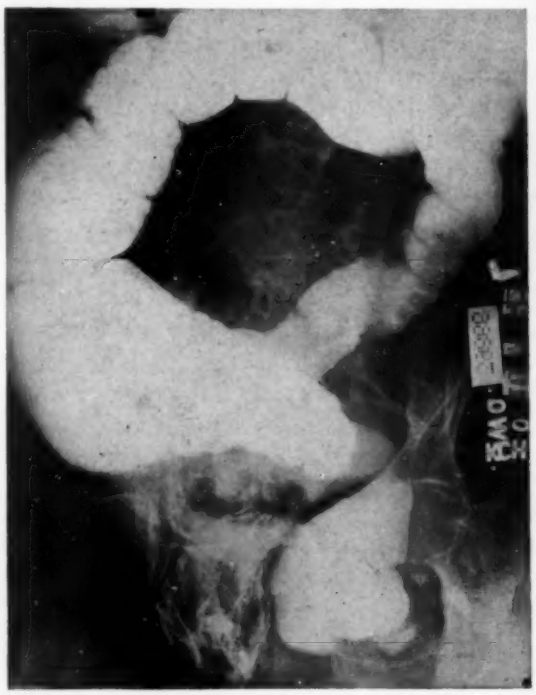

FIG. 2. Case 1. The barium enema flowed freely through the entire colon. No mechanical lesion. Autopsy showed gangrenous intestine due to mesenteric thrombosis.

woman in acute abdominal distress. No dyspnea or orthopnea.

The heart was moderately enlarged to percussion. A soft systolic murmur was present over the apex. The heart rate was 110, and totally irregular. There was no pulse deficit.

The abdomen was distended. There was slight tenderness throughout the abdomen, especially on the left side. No borborygmi were heard. There was no rebound tenderness or rigidity and the abdomen was soft. A small hernia was palpated in the right inguinal region.

The rectal examination showed external hemorrhoids.

There was one plus ankle edema. Arthritic changes were noted.

The temperature was 99° F.; respiratory rate 24; blood pressure 160 systolic and 90 diastolic.

Fig. 3. Case II. Distention of the small intestine and proximal half of the colon corresponding to the distribution of the superior mesenteric vessels. The distention simulates a mechanical lesion. Three feet of gangrenous ileum removed, with recovery of the patient. Hemorrhagic infarction in small bowel.

Fig. 4. Case III. Distention of proximal colon down to splenic flexure. Four feet of gangrenous ileum removed, with recovery. Venous thrombosis found.

Surgical intervention was postponed because of fibrillation, dehydration and poor general condition.

On the day after admission, follow-up notes record the condition of cardiac failure, with fibrillation. The abdomen was moderately distended but soft, with tenderness mostly confined to the left lower quadrant. No masses were felt. Rectal examination showed feces present. Temperature was normal. Leukocyte count was 10,400; erythrocyte count, 3.9 million; hemoglobin, 75 per cent.

Another clinician recorded that there was no visible or audible peristalsis. Paralytic ileus or volvulus was also considered in the differential diagnosis.

Electrocardiogram showed auricular fibrillation and myocardial damage. Urinalysis showed a few granular casts, a few red blood cells and leukocytes, two plus albumin, no sugar.

The patient died the following day.

Autopsy Findings. There was about 150 cc. of a brownish-yellow fluid in the abdominal cavity. Both large and small intestines were

markedly distended. The entire small intestine, the cecum and ascending colon were dark purple in color and appeared gangrenous. The gangrenous area in the cecum and ascending colon gradually diminished in severity and in intensity as to color as one progressed distally. Many loops of small intestine were loosely adherent to each other and to the floor of the pelvis by a yellow plastic material. No evidence of herniation of any part of the intestines.

The gastrointestinal tract was then opened from the esophagus to the rectum.

The entire small intestine and cecum showed a purplish mucosa. On section the entire wall of the above intestine showed a gangrenous purplish surface. The superior mesenteric artery was traced throughout and about 2 inches distal to the aorta at the base of the mesentery of the small intestine, a large thrombus was found, about 3 inches in length, completely occluding the artery. There was no evidence of cancer in the small or large intestine.

Anatomical Diagnosis:

1. Thrombosis of the superior mesenteric artery with gangrene of the small bowel, cecum and part of the ascending colon.
2. Hypertensive arteriosclerotic heart disease.
   (a) Myocardial hypertrophy.
   (b) Arteriosclerotic mitral sclerosis.
   (c) Atherosclerosis of the aortic valves, moderate.
   (d) Coronary sclerosis, marked.
3. Atherosclerosis of the aorta, marked.
4. Arterial nephrosclerosis.
5. Nutmeg liver.
6. Emphysema of the lungs.

CASE II. In this case a plain roentgenogram was obtained preoperatively and a diagnosis of possible mesenteric thrombosis or obstruction was offered by the striking resemblance to the findings in Case 1, namely, distention of the small intestine and proximal half of the colon, with an abrupt stop to the air column at the left and of the transverse colon. Operation was performed before any further roentgen investigation was made and 36 inches of gangrenous gut was resected with findings of extensive hemorrhage and vascular engorgement of the mesentery.

J. A., white Italian female, aged eighteen. The patient was admitted in July, 1943, with complaints of abdominal pain, vomiting and rectal bleeding for a period of eighteen hours since the onset. The pain started in the epigastrium and then localized to both lower quadrants. It was colicky in type, persistent, with cramp-like exacerbations mainly in the left lower quadrant, and radiated to the back. The patient had vomited all ingested food and fluids since the onset. One bowel movement occurred. A subsequent enema was nonproductive. Later the patient passed maroon-colored blood by rectum on two occasions. The pain became progressively worse.

There was a history of syphilis and a positive Wassermann reaction.

No previous similar attacks had been experienced. The patient had just completed a menstrual period, which was normal. An appendectomy was performed four months prior to this admission.

Physical examination of the abdomen revealed a healed scar in the right lower quadrant. The upper portion of the abdomen was scaphoid, and the part below the umbilicus was distended. The liver, spleen and the kidneys were not palpable. The abdomen was diffusely tender, with rebound most marked in the lower quadrants. No masses were felt. Borborygmi were heard over the lower quadrants. The patient appeared poorly nourished and anemic. The general condition was said to be not good. The heart and lungs were negative.

The clinical diagnosis was acute intestinal obstruction with strangulation.

At operation a large amount of serosanguineous material was found in the abdomen and a considerable amount of gangrenous gut. Three feet of ileum were resected and an ileostomy done.

Pathological Report. Gross: "The specimen consists of approximately 36 inches of intestine, with a small portion of mesentery attached and showing several loops. The serosal surface is dull gray, dark brown and bright red in other areas. It appears to contain some gas and has a fetid odor. On section, the specimen emits bloody fluid. The mucosal surface is dull and brown in color, and shows some irregular greenish-brown areas."

Microscopic: "Section of small bowel characterized by marked mural edema, congestion, hemorrhage and necrotizing changes involving all coats. Areas of infiltration with polymorphonuclears and lymphocytes noted. The mesentery is likewise the seat of extensive

hemorrhage, vascular engorgement and infiltration with leukocytes. Diagnosis: hemorrhagic infarction of small bowel."

A secondary operation was done at a later date to establish bowel continuity following ileostomy.

The patient made a complete recovery.

Case III. In this case also, a preoperative plain roentgenogram of the abdomen showed distention of the right half of the colon down to the splenic flexure, while the colon distal to this was not dilated. The attending surgeon had made a clinical diagnosis of mesenteric vascular occlusion and operated immediately before further roentgen studies were obtained. Operation disclosed mesenteric thrombosis. The patient recovered after bowel resection.

M. F., colored laborer, aged thirty-nine, admitted on February 19, 1943, to Kings County Hospital for treatment of a hematoma of the buttock, following trauma. Blood was evacuated from a cystic hematoma of the right buttock eighteen days after injury. The past history was negative save for a neisserian infection five years before.

One week after the operation on the buttock, the patient experienced sudden cramping lower abdominal pain after an enema. Vomiting and tenesmus were present. The abdomen was soft and not tender. The clinical impression was gastroenteritis. The temperature was 100.6° F., pulse 86, respirations 26, blood pressure 112/96.

Another observer: The abdomen was mildly distended, with a tympanitic note heard throughout except the left lower quadrant and the left flank where the note is flat. Dullness does not shift. Pain and tenderness in these same areas. No spasm or rebound. Rectal examination showed no tenderness, no blood, tonus good. Impression: Intestinal obstruction, hemorrhagic in origin. Clotting time was $5\frac{3}{4}$ minutes (Lee and White method).

Another observation at 9:45 P.M.: Patient in no acute pain but still has distention. High soap suds enema ineffectual. Leukocyte count 28,000, with 90 per cent polymorphonuclears. Therapy: Harris drip, infusion, Wangensteen tube.

At 10:45 P.M.: Patient complains of hiccough. In no acute pain. Abdomen still distended, tender in left upper quadrant and down the left side. Occasional peristaltic sound heard on auscultation. Diagnosis by Dr. Laurence G. Bodkin (service of Dr. Joseph Tenopyr): "Soft distention, high blood count, absence of definite obstructive symptoms. Opinion: mesenteric vascular occlusion."

At operation (March 10, 1943) there was found gangrene of the ileum to within 4 inches proximal to the cecum. The ileum was blackish in color, with thrombosis of the mesenteric vessels. Free, thick, colorless fluid in large amounts. Four feet of ileum was removed.

Pathological Report. Specimen consists of a piece of small intestine which measures 51 inches in length. The serosal surface is dark brown in color. The mesentery is slightly thickened. The gut feels thickened in its entirety. There is a markedly edematous mucosa and an easily friable wall.

Microscopic: Very marked mural edema of small gut with congestion and extensive interstitial hemorrhage, especially marked in the mesentery. Areas of polymorphonuclear invasion together with focal areas of necrosis noted. The findings were considered to indicate venous thrombosis, probably due to mechanical cause.

The patient made a normal recovery.

SUMMARY AND CONCLUSIONS

The preoperative diagnosis of mesenteric thrombosis is difficult, yet its early recognition offers an excellent opportunity for bowel resection and complete recovery.

Roentgen examination of the acute abdomen and in this particular disease has in the past been too often neglected by the attending physician and the surgeon.

The clinical finding of distention is very common in mesenteric thrombosis, according to the literature.

Three proved cases are reported in which the most striking roentgen finding was localized distention of the intestine simulating a mechanical obstruction, but having a distribution which corresponded to that of the superior mesenteric artery, with an abrupt demarcation of the distended intestine near the splenic flexure of the colon. In one case a barium enema passed freely through the distended intestine. One patient died. The other two patients made a complete recovery after bowel resection.

Although these are new concepts, the roentgen findings in our three cases suggest

that the possible diagnosis of thrombosis of the superior mesenteric vessels should be among those considered when the plain roentgenogram of the abdomen discloses bowel dilated down to the region of the splenic flexure, simulating a mechanical obstruction. If a subsequent barium enema reveals no obstruction, it is believed that the diagnosis may be ventured with some probability.

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GIANT HEMANGIO-ENDOTHELIOMA WITH THROMBOCYTOPENIC PURPURA

RESULTS OF ROENTGEN THERAPY

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GIANT hemangio-endothelioma associated with thrombocytopenic purpura is a combination of great rarity. Only one other comparable case has been reported in the medical literature. This unusual case is presented first, because of the rarity of its occurrence, and second, because of the excellent therapeutic results obtained from roentgen therapy.

J. D., an infant, aged six months, was admitted in critical condition to the Flower and Fifth Avenue Hospitals by transfer ambulance from Metropolitan Hospital. Transfer was considered necessary because the tumor on the child's back suddenly began to swell. This enlargement was accompanied by a tendency to hemorrhage. The infant was admitted to Flower and Fifth Avenue Hospitals for deep roentgen therapy.

On admission, the patient was a well developed and well nourished white male infant who was deformed by an extensive tumor covering the upper half of his chest, anteriorly and posteriorly, on the left side, and extending across the neck onto the lower part of the face, and also on the left arm. The tumor was firm and did not pulsate. It showed no areas of degeneration or infection. There was, however, a small healing wound at the point of the left shoulder where a part of the tumor was excised for biopsy. The tumor was ecchymotic and had a blue discoloration. There were hemorrhagic spots around the base of the tongue, soft palate, fauces and pharynx. No actual hemorrhage was discerned. The spleen was palpable one finger breadth below the costal margin. The remainder of the physical examination was negative.

The child's mental development was average for his age. The family history was not contributory.

The laboratory findings at this time were: Complete blood count—hemoglobin 9.2 grams; red cells 3 million; white cells 15,200; platelets 15,000 by direct method; coagulation time four minutes; bleeding time twenty-five minutes. The Wassermann reaction was negative. A roentgenogram of the left shoulder and neck was taken on May 7, 1942, and showed evidence of the soft tissue tumor mass but no evidence of bone or joint disease.

The child was born at home on November 21, 1941, by spontaneous delivery (breech) and was a full term 7½ pound normal white male. At birth a crescentic mass was noted on the back extending from the midline to the left shoulder and the diagnosis of "lipoma" was made.

In January, 1942, the tumor became larger and showed a bluish discoloration which blenched on pressure. Small areas of ecchymosis and petechiae were noted all over the body.

He was admitted to New York Hospital on March 5, 1942, where the initial laboratory reports revealed low hemoglobin, low red blood count, markedly diminished platelet count and prolonged bleeding time. Here the diagnosis of hemangioma with thrombocytopenic purpura was made. The mass continued to increase in size with marked discoloration despite vitamin K and numerous small transfusions. One treatment of deep roentgen therapy, 220 r at 140 kv. (peak) with 1 mm. Al filter at 25 cm. distance, was given without appreciable effect.

One week later the infant was admitted to Metropolitan Hospital where the laboratory findings were similar to those found at New York Hospital. Here the child was given supportive therapy including blood transfusions and vitamin K. The mass gradually extended to the left side of the face and chin and down to the last rib on the left side (Fig. 1 and 2).

On May 4, following an upper respiratory infection his throat became hemorrhagic. The uvula was edematous and showed hemorrhagic spots.

The next day the pharynx was more hemorrhagic with many spots that bled easily. The child now had a laryngeal cry and looked criti-

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cally ill. It was deemed advisable at this time to refer the child for roentgen therapy, and he was therefore transferred to the Flower and Fifth Avenue Hospitals.

The first two courses of deep roentgen therapy were given between May 8 and June 30, 1942.

The first course, given from May 8 to June 1, consisted of a total of ten treatments of 100 r each through portals of 7 by 7 cm. and 10 by 10

FIG. 1

cm. using 140 kv. (peak) through 3 mm. Al filter at a distance of 50 cm. The whole tumor was not treated at one time but was marked off into four major sections, each area receiving 200–300 r, measured in air, as follows (slight overlapping could not be avoided): (1) laterally to left side of neck—300 r; (2) laterally to left shoulder—200 r; (3) left shoulder anteroposteriorly—300 r; (4) left shoulder posteroanteriorly —200 r.

After an interval of two weeks, during which time there was but a slight regression of the tunor and no change in the blood picture, a second series of six treatments was given from June 16 to 30. Three areas were treated—the neck, shoulder anteroposteriorly and shoulder posteroanteriorly. Each area received 200 r. The same factors were used in this series as were used in the first series, with a total dosage of approximately 700 r.

Supported by small transfusions, the child showed some improvement under this therapy with some regression of the tumor mass. The abnormal bleeding time varied between eleven and thirty minutes, and the platelet count remained low, between 15 to 80,000 c. mm. The baby's physical and mental development was never at any time impaired or retarded and the child continued to develop normally.

On July 25, the growth again began to enlarge in all directions. The tumor was boggy and edematous to palpation. The blood findings at this time were as follows: bleeding time eight minutes and platelet count 240,000 per c. mm.

By August 10, 1942, the bleeding time had risen to fifty minutes and the platelets had fallen to 60,000 per c. mm. (Chart 1).

The next day new purpuric areas appeared on the chin and chest of the baby. Therefore, we decided to start another course of deep roentgen therapy but with a variation in type and dosage, as follows:

On August 11, posteroanteriorly to the back and left shoulder, a dose of 275 r, measured in air, was delivered with only the inherent filtration (approximately 0.15 mm. Cu) of the tube at a distance of 25 cm. using an open field and 160 kv. (peak).

On August 13 and September 1 to the same area 275 r was delivered through a 20 by 20 cm. portal using 160 kv. (peak) with 3 mm. Al filter, at a distance of 50 cm.

FIG. 2

On October 22, laterally to the neck and shoulder 275 r was delivered through a 10 by 10 cm. portal using 160 kv. (peak) and a 3 mm. Al filter, at a distance of 50 cm.

The child responded very well to the treatment. In two months the mass had regressed so much that the normal body contours appeared. The underlying bony prominences became palpable for the first time. The discoloration of the skin persisted and faded slowly.

On October 14 the baby developed a generalized erythematous vesiculopapular eruption. No cause could be found for this lesion. However, it started to disappear spontaneously and

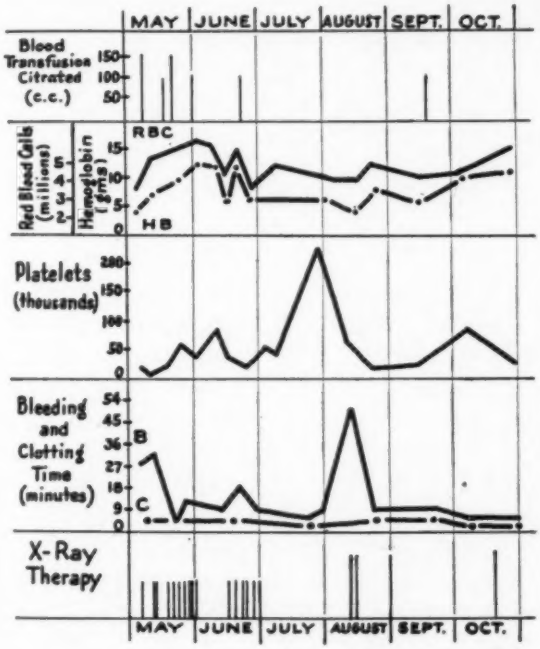

Chart 1

the child was discharged from the hospital on October 31, 1942.

The report of the biopsy of the tumor taken at Metropolitan Hospital was as follows: "There are areas showing large numbers of small vessels lined by neoplastic endothelium. The lumen of the vessel is small and obliterated in some places. In these areas the tumor shows marked cellularity. Those areas are intercepted by large amounts of fat tissue. Diagnosis—hemangioma hypertrophicum (hemangio-endothelioma)" (Fig. 3).

The child was seen on March 4, 1943, one year after his admission to Metropolitan Hos-

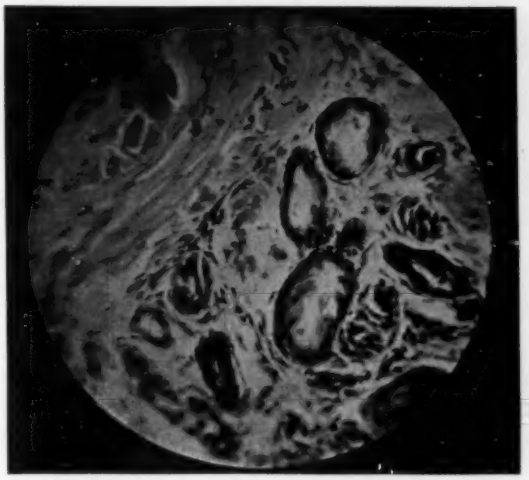

Fig. 3

pital (Fig. 4 and 5). At this time most of the skin had a normal appearance except for a small area on the arm which showed some purplish discoloration due to recent bleeding. In the region of the shoulder the skin is roughened, slightly raised and red. Both areas were given a single dose of 275 r through a 10 by 10 cm. portal using 160 kv. and a 3 mm. Al filter at 50 cm. distance.

One month later, on April 4, 1943, he was again examined. The purple areas had disappeared but the reddened area was unchanged. The bleeding and clotting times were four and a half minutes and one and a half minutes respectively, and the platelet count was 450,000 per c. mm. At the present time the child is developing normally. He is of average intelligence, active and alert.

In determining the type and dosage of roentgen therapy to be given to the tumor mass we had but little precedent to follow. Kasabach and Merritt,[1] in their case, used a combination of roentgen and radium therapy. In this patient the mass never became localized sufficiently for us to expect to get satisfactory results from the use of radium. Inasmuch as we used roentgen radiation alone we had therefore to increase the amount suggested by Kasabach and Merritt. From the effect noted in the first and second series of treatments, the amount and total radiation were apparently insufficient; however, the latent effect of the roentgen dosage could not be evaluated at

FIG. 4

FIG. 5

this time. Therefore, larger doses were given with prompt and effective response. This response manifested itself not only in the regression of the tumor, but also in the elevation of the platelet count and in the lowering of the bleeding time with a corresponding disappearance of the purpura. Since the radiation delivered to the tumor was also effective on the spleen, ribs and long bones, it is difficult to ascertain whether the beneficial effect on the thrombocyte count was due to the roentgen therapy to the tumor alone or its additional effect on the spleen and long bones combined.

SUMMARY

We have presented the case of an infant who had a giant hemangio-endothelioma covering the left side of the face and the left shoulder and thorax, associated with thrombocytopenic purpura. This tumor was diagnosed by biopsy and was treated successfully with heavy doses of deep roentgen therapy which caused regression of the tumor mass and disappearance of the purpura, with a restoration of the normal blood picture.

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DIRECT VISUAL GUIDANCE, TRIANGULATION ROENTGENOSCOPY IN THE REMOVAL OF OPAQUE FOREIGN BODIES

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THE numerous articles in regard to various methods of localization of foreign bodies, particularly those pertaining to depth measurements for guidance of the surgeon in removing them, have stimulated the reporting, in more minute detail, my experience with my own apparatus. This apparatus, previously described,* relies on no measurements but rather on direct visual guidance at the time of operation.

In endoscopy and eye work the removal of foreign bodies cannot be done by surgical exposure, except for an extremely small opening through the wall of the eyeball. This opening must, necessarily, be no larger than enough to admit a Cross loop forceps. Of course, in the case of magnetic foreign bodies, in the eye, the usual localization guides the surgeon as to the point of application of the electromagnet. However, we see non-magnetic foreign bodies in the eye, such as B.B. shot, shot of various sizes from shot gun shells, pieces of brass or other alloys. These non-magnetic foreign bodies of the eye and opaque foreign bodies of the food and air passages are the ones with which we are concerned at this time. They present a problem in which no amount of measurement will be of even the slightest aid to the surgeon. These must be removed under direct, accurate visual guidance at the time of operation. Any method which will guide the surgeon quickly and accurately in removing such foreign bodies should facilitate, even more, the removal of those which require surgical exposure, such as bullets in soft tissue.

In the past the removal of opaque foreign bodies in the eye (non-magnetic), the food and air passages has been accomplished by biplane roentgenoscopy. This, as anyone knows who has tried it, is cumbersome and slow. Being apparently lined up in one plane, with a biplane roentgenoscope, may be far from the foreign body in the other

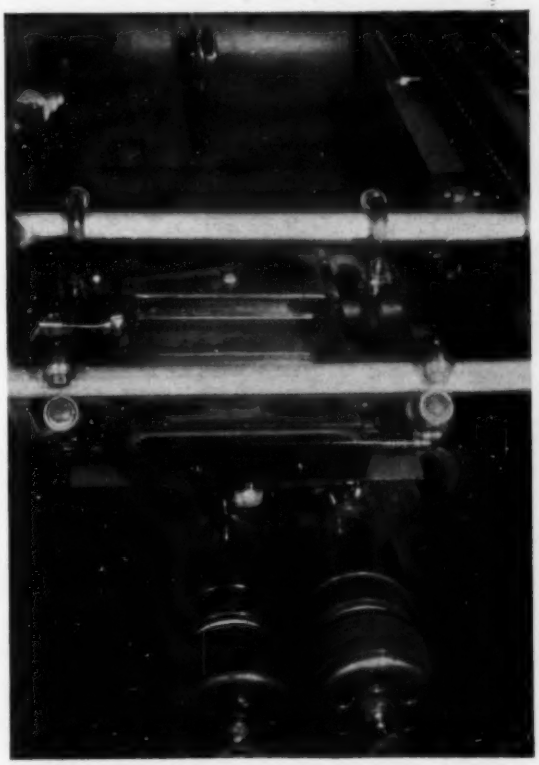

FIG. 1. Roentgenologic tilt table top removed showing the triangulation roentgenoscopic assembly. Note roentgen tubes in parallel. Three wire system to the cathodes, one wire common. Anode, one wire with short wire connecting the two anodes. One tube set so that rays are at right angle to the table top as for conventional roentgenoscopy, the other tilted slightly so that rays intersect those of the first tube for triangulation roentgenoscopy. The first tube can be used independently of the second tube by a single switch on the control panel.

* Roberts, W. E. New method of guidance-triangulation fluoroscopy in the removal of opaque foreign bodies. *South. Med. & Surg.*, August, 1938, *100*, 385–386.

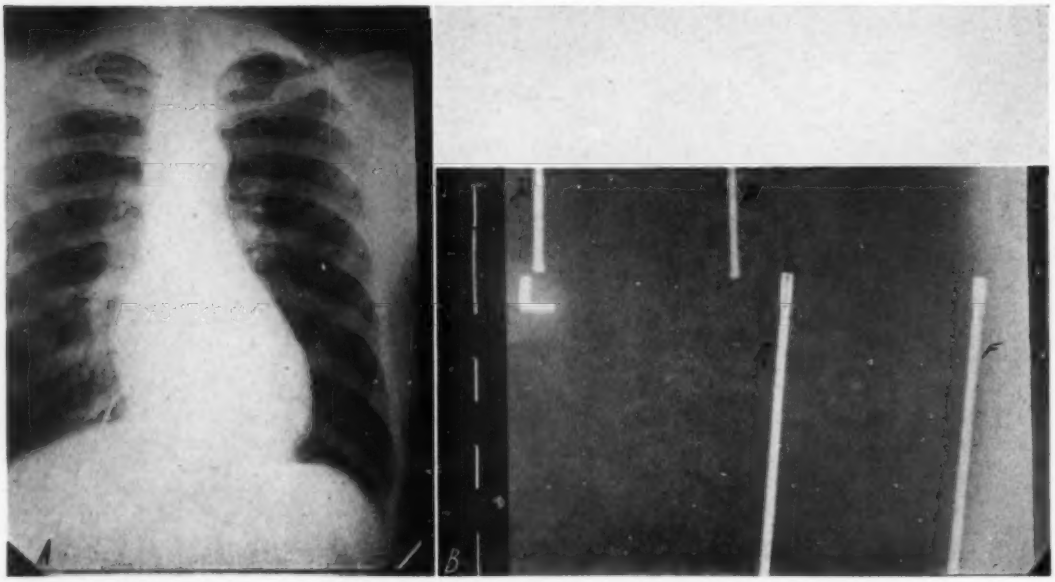

FIG. 2. *A*, roentgenogram showing a finishing nail adjacent to the heart shadow in the extreme base of the right lung. Nail removed through the bronchoscope under triangulation roentgenoscopic guidance. *B*, roentgenogram made on model illustrating forceps shadows to the right of the foreign body shadows (patient on back, prone on table for all illustrations). One foreign body and one forceps but two images on the film or fluoroscopic screen in this figure and Figures 3, 4, 5, 6*B*, 7 and 8. D_1D, shadows of the foreign body; F_1F, shadows of the forceps.

plane. Biplane work requires constant shifting from one plane to the other.

This is completely overcome with my present apparatus, the triangulation roentgenoscope (Fig. 1). Only one fluoroscopic screen is used and from this any and all positions of the foreign body, forceps, or probe can be determined. Every movement of foreign body or instrument is before the roentgenoscopist at all times, in all three planes. All three dimensions are observed as instantaneously as the pulsation of the heart in conventional single plane roentgenoscopy. Triangulation roentgenoscopy is not three dimensional in the sense of

FIG. 3. Forceps shadows farther apart than the foreign body shadows. Too far posterior, in other words forceps nearer the tubes than the foreign body. D_1D, shadows of the foreign body; F_1F, shadows of the forceps.

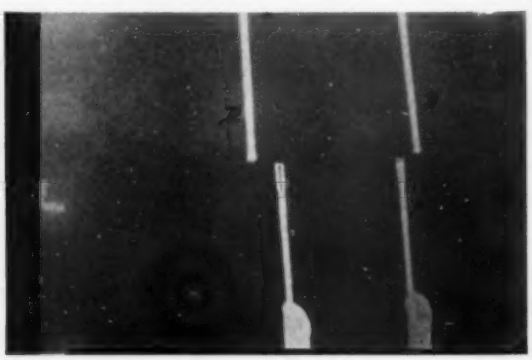

FIG. 4. Forceps shadows closer together than the foreign body shadows. Forceps too far anterior (forceps farther away from the tube than the foreign body). D_1D, shadows of the foreign body; F_1F, shadows of the forceps.

stereoscopic vision. All dimensions are obtained by positions and relations on a single screen and visible at all times.

As will be noted in Figure 1, there are two roentgen tubes mounted in parallel on a single tube carriage of special design instead of the usual single tube for roentgenoscopy. These two tubes are so mounted as to permit setting them at any desired angle. I keep one tube in the usual position used in single plane roentgenoscopy, i.e. the rays are projected at right angles to the table top. The other tube is adjusted at an acute angle so that the rays intersect those of the first tube, in other words, cross fire.

The two roentgen tubes are of identical design and capacity. They are so wired through the control panel that one or both can be used by simply turning a single hand switch. Each tube has its own filament rheostat control. The filament current is then adjusted so as to give 5 ma. on the first tube. Then the second tube is thrown into the circuit and the filament adjusted to read 10 ma. (5 ma. on each tube). The two tubes are activated simultaneously through a single foot switch and the radiation from both is projected through the same shutter assembly. This shutter assembly is of special design, having a larger portal than the usual fluoroscopic shutters. As a result of both tubes being activated at the same time, cross fire, there are two shadows of the foreign body on the fluoroscopic screen instead of one. Any other opaque object which comes into the field, such as a pair of forceps or probe, will also produce two shadows on the fluoroscopic screen (Fig. 2*B*, 3, 4, 5, 6*B*, 7 and 8).

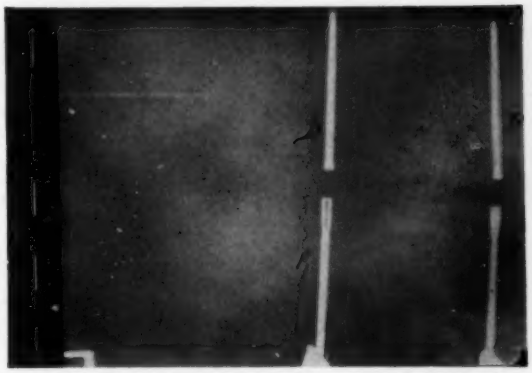

Fig. 5. Forceps and foreign body in the same plane, vertically and horizontally, because the forceps and foreign body are equidistant from the tubes. D_1D, shadows of the foreign body; F_1F, shadows of the forceps.

Consequently all that is necessary to inform the surgeon as to his instrument's position in regard to the foreign body is to observe the distance between the two shad-

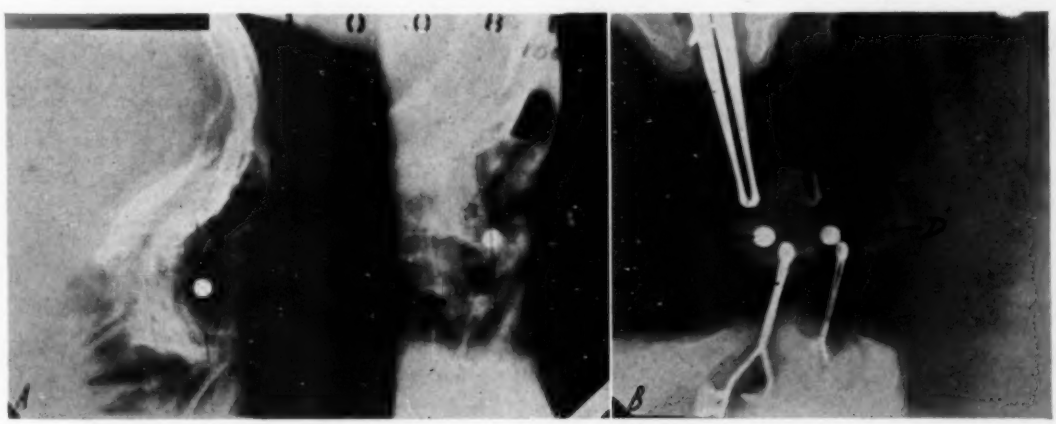

Fig. 6. *A*, roentgenograms made to determine whether B.B. shot was inside the eye or in the orbital tissue. B.B. shot was inside the eye. *B*, roentgenogram made on "dummy" model to illustrate triangulation roentgenoscopic guidance for removal. D_1D, shadows of the foreign body (B.B. shot); F_1F, shadows of Cross loop forceps. Forceps above and to the right of the foreign body.

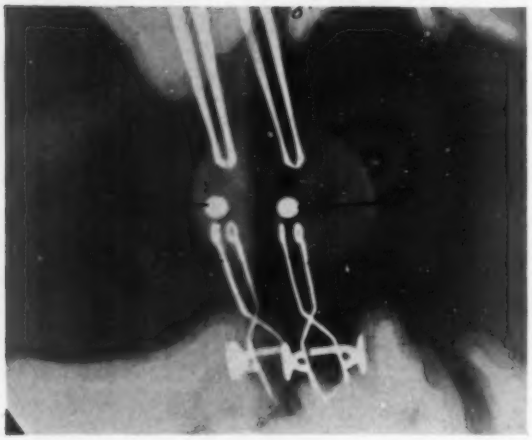

Fig. 7. Same as Figure 6*B* except Cross loop forceps are in the same plane as the foreign body because the shadows of the foreign body and forceps are equidistant. D_1D, shadows of the foreign body; F_1F, shadows of the forceps.

ows of the foreign body and the distance between the two shadows of the instrument. In bronchoscopy, the patient is placed on the table on his back and thus if the roentgenoscopist reports the forceps too far anterior we understand that means too far toward the ventral surface; too far posterior, too far toward the dorsal surface. Right and left are the same as the bronchoscopist's right and left. For example, in the lung, if the two instrument shadows are to the right of the foreign body shadows (Fig. 2*B*) the instrument is too far to the right even though it may be in the proper horizontal plane. Conversely, the same is true to the left. Now if the instrument is introduced too far posteriorly, this means that the instrument is nearer the fluoroscopic roentgen tubes than the foreign body and the two shadows of the instrument will be farther apart on the fluoroscopic screen than the two shadows of the foreign body (Fig. 3). If the instrument is introduced too far anteriorly, the instrument is farther from the tubes than the foreign body and the two shadows of the instrument will be closer together than the shadows of the foreign body (Fig. 4), just the reverse of Figure 3. When the instrument is introduced into the proper plane (the same plane as the foreign body both vertically and horizontally, and not to the right or left), the distance between the two shadows of the foreign body and the distance between the two shadows of the instrument will be the same, and in direct apposition to each other (Fig. 5). This is true because the forceps and the foreign body are equidistant from the roentgen tubes. Now, when the instrument is advanced to the foreign body the shadows of the foreign body and the tip of the instrument are in contact because they are in the same plane in all directions. In the case of the eye we have a slightly different situation as the patient must be placed on the roentgenoscopic table on his side. All that is necessary is to decide the nomenclature of the directions so that the surgeon will understand the directions given by the roentgenoscopist. Figure 6*A* shows a shot in the left eye. Figures 6*B*, 7 and 8 illustrate, on a dummy model, the double shadows as seen on the fluoroscopic screen when using the triangulation roentgenoscope. Frequently in the eye it is difficult to approach the foreign body even though the forceps are in the proper plane because the shot will move about very freely instead of being fixed as those in a terminal bronchiole. However, once arriv-

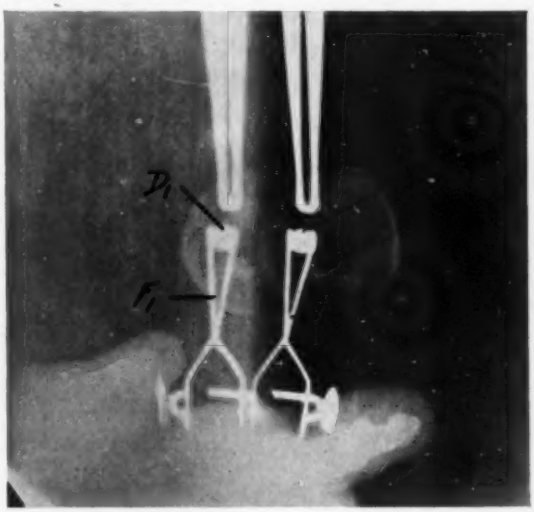

Fig. 8. Foreign body grasped by Cross loop forceps and removed. D_1D, shadows of the foreign body; F_1F, shadows of the forceps.

ing in the proper plane (Fig. 7), if the jaws of the Cross loop forceps are kept apart sufficiently the foreign body may be approached without shifting position and grasped easily (Fig. 8). Any movement out of the proper plane is quickly detected since all directions are continuously before the roentgenoscopist.

The description is necessarily long but actually only a glance at the fluoroscopic screen is necessary to determine the position of the surgeon's instrument in regard to the foreign body. Just as rapidly as the instrument is moved the roentgenoscopist who understands the underlying principle of the triangulation roentgenoscope can report to the surgeon where his instrument is in relation to the foreign body. No one plane or dimension is considered separately as in biplane or measurement. All dimensions are plainly visible at a glance at all times and the relation of the instrument and the foreign body can be described as rapidly as shadows are described in single plane roentgenoscopy.

The only other variation from the conventional roentgen table is a false table top. This is a simple wooden top elevated by wooded supports to about 10 or 12 inches above the usual table top. This false top is secured to the regular tilt table by an immobilizing band. The function of this false top is to gain distance from the roentgen tubes so as to eliminate, as much as possible, any distortion.

A calibration in roentgens is done frequently with both tubes functioning so that an accurate check can be kept on the dosage any patient receives at any given time. In addition, I have a self starting electric clock wired into the circuit so that a reading can be made at the start of roentgenoscopy; and at any time during the operation the elapsed time may be determined and thus the number of roentgens calculated.

This method, which has been successfully used in this laboratory in numerous cases over a period of six years, has many advantages. No measurements are made or needed. This cannot be over-emphasized. The surgeon and roentgenoscopist work together as a team at the time of operation, not independently as in measurement or calculation. In some parts of the body, such as the eye (non-magnetic foreign bodies), the esophagus and the terminal bronchioles of the lung, measurements are worthless. It would seem that any method such as this one which guides accurately and quickly in such parts as the lung, food passage and eye would be very valuable where surgical exposure is indicated. The procedure gives all dimensions at a single glance, thus speeding up the whole procedure to the comfort of the patient and all concerned. The apparatus is all shock proof and a part of the roentgenologic tilt table the same as any single plane roentgenoscope. This roentgenoscopy need not exclude light in the room. A head operating fluoroscopic screen can be used just as well as the usual screen. Consequently it would seem that this method, which is rapid and accurate, being based on triangulation, could be used for the removal of any opaque foreign body anywhere in the human body.

The 2 cases* illustrated in Figure 2*A* and 6*A* were selected from the 16 so far recorded.

* Bronchoscopy done by Dr. V. K. Hart and eye surgery by Dr. Frank C. Smith.

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Forty-fourth Annual Meeting: Joint Meeting of the American Roentgen Ray Society and the Radiological Society of North America, Palmer House, Chicago, Ill., Sept. 24–29, 1944.

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Representatives on American Board of Radiology: Douglas Quick, New York, N. Y., B. P. Widmann, Philadelphia, Pa., F. W. O'Brien, Boston, Mass.

Twenty-eighth Annual Meeting: 1944, to be announced.

EDITORIALS

THE PROBLEM OF CASTRATION IN MAMMARY CANCER

IN A former issue of this JOURNAL[1] the estrogenic theory of mammary carcinoma was expounded and the implications of such a theory on clinical radiotherapeutic considerations discussed. At that time the question was raised as to whether or not the routine castration of every patient afflicted with mammary carcinoma might not help improve the results over a long period of time through destruction of the estrogen producing source. The clinical and experimental material available, however, appeared contradictory and no tangible conclusions could be reached.

Since then, progress has been more swift, and interest, especially in the various groups of hormonal cancers, has become much keener. It, therefore, may not prove altogether futile to try to review the subject in the light of the newest contributions.

A connection between mammary cancer and sex function was suspected from the earliest days and thus it is not surprising that the first attempts at castration should have been made by surgical approach, before radiation therapy even existed.

Schinzinger,[2] as far back as 1889, proposed the surgical removal of the ovaries in young women with carcinoma of the breast, believing that the induction of artificial menopause would slow down the progress of the cancer.

Beatson,[3] in 1896, reported favorable results by a similar procedure in illustrative cases of inoperable mammary carcinoma. He noted in a number of instances shrinkage of the primary carcinoma as well as regression of the cutaneous and lymphatic metastases. On the basis of histologic studies of such cases, he made the definite statement that "the surgical removal of the tubes and ovaries has effect on the local proliferation of epithelium which occurs in cancer of the mamma, and helps on the tendency cancer naturally has to fatty degeneration." Boyd,[4] Thomson,[5] Lett[6] and Torek[7] reported additional series of cases with the favorable results varying between 23 and 41 per cent. The effect always appeared more impressive in the premenopausal period. Interest in the surgical procedure then gradually waned until very recently. In April, 1944, a notable contribution was made by Horsley[8] who published his results in a series of 25 cases which had been oöphorectomized since November, 1937. What seems to have induced Horsley to adopt surgical castration routinely is the disappointing experience he has had with radical mastectomy in cancer of the breast in young women. At first he did bilateral oöphorectomy with radical operation only on patients under forty years of age, but

[1] Leucutia, T. Irradiation and the estrogenic theory of mammary carcinoma. AM. J. ROENTGENOL. & RAD. THERAPY, 1941, *45*, 923–925.

[2] Schinzinger. Das Karzinom der Mamma. *München. med. Wchnschr.*, 1905, *52*, 1724–1725.

[3] Beatson, G. T. On the treatment of inoperable cases of carcinoma of the mamma; suggestions for a new method of treatment with illustrative cases. *Lancet*, 1896, *2*, 104–107; 162–165.
Beatson, G. T. The treatment of inoperable carcinoma of the female mamma. *Glasgow Med. J.*, 1911, *76*, 81–87.

[4] Boyd, S. On oophorectomy in cancer of the breast. *Brit. M. J.*, 1900, *2*, 1161–1167.

[5] Thomson, A. Analysis of cases in which oöphorectomy was performed for inoperable carcinoma of the breast. *Brit. M. J.*, 1902, *2*, 1538–1541.

[6] Lett, H. An analysis of 99 cases of inoperable carcinoma of the breast treated by oöphorectomy. *Lancet*, 1905, *1*, 227–228.

[7] Torek, F. Disappearance of recurrent mammary carcinoma after removal of the ovaries. *Ann. Surg.*, 1914, *60*, 476–477.

[8] Horsley, J. S. Bilateral oöphorectomy with radical operation for cancer of the breast. *Surgery*, April, 1944, *15*, 590–601.

later the method was extended to all patients in the premenopausal stage. It is Horsley's contention that complete abolition of all ovarian function cannot be brought about by roentgen irradiation, however exact the technique of administration may be. Surprisingly, a study of the final outcome in his cases reveals that only 2 recurrences developed in the entire series although 19 cases were operated on from fourteen months to six years previously. One recurrence was noted in a patient with bilateral mammary cancer, who doubtless had internal metastases at the time of operation, notwithstanding the fact that they could not be demonstrated then, and the other was in a patient with mucoid cancer.

Castration by means of roentgen rays (and radium), although introduced considerably later, has created an interest which far surpasses that of the surgical approach. A very voluminous literature has sprung up dealing with all possible phases of the procedure. In an important article, Ahlbom,[9] by summarizing the investigations up to 1930, expressed the opinion that routine roentgen castration does not lead to prolongation of life in the average case of cancer of the breast nor does it diminish the incidence of metastatic extension. Moreover, the climacteric symptoms induced prematurely often constitute an unnecessary burden. This viewpoint continued to dominate the literature and was endorsed only very recently by Ritvo and Peterson[10] who make the categoric statement that in the light of present day knowledge routine ovarian sterilization of all patients with cancer of the breast in the premenopausal age period is inadvisable. A statistical survey made of a rather large number of cases treated at Harper Hospital in Detroit[11] revealed that if the final results were classified according to age incidence, the poorest results were obtained in the group between fifty and fifty-nine years, that is immediately after the onset of the normal menopause. A priori, this observation also seems to support the opinion that routine roentgen sterilization of every case of mammary cancer constitutes a futile and valueless effort.

Yet there is one phase in connection with the roentgen suppression of ovarian function in cancer of the breast which contradicts such a standpoint. It has been repeatedly observed that osseous metastases secondary to cancer of the breast often regress or disappear completely following roentgen sterilization. Ritvo and Peterson[10] after a survey of the literature, believe that one-third or more of the patients so treated may be expected to show improvement and prolongation of their period of usefulness although they are not certain that a prolongation of life is obtained at the same time. Likewise it is not clear—despite some very striking reports in the literature—whether local recurrences and visceral metastases present a similar degree of response attributable to roentgen treatment of the ovaries.

A consideration of the results of pertinent animal experiments may perhaps furnish one or two leads. In 1927, Cori[12] carried out a series of very illuminating investigations on the influence of bilateral oöphorectomy on the spontaneous occurrence of mammary carcinoma in mice. For this purpose he used pure strains which were developed by March and in which after eight inbred generations over a period of five years the cancer rate and cancer age varied but little. The non-breeding females which were used for control exhibited a cancer incidence of 78.5 per cent and an age of maximum cancer rate of fourteen to fifteen months. The experi-

[9] Ahlbom, H. Castration by roentgen rays as an auxiliary treatment in radiotherapy of cancer mammae at Radiumhemmet, Stockholm. *Acta radiol.*, 1930, *11*, 614–633.

[10] Ritvo, M., and Peterson, O. S., Jr. Regression of bone metastases from breast cancer after ovarian sterilization. AM. J. ROENTGENOL. & RAD. THERAPY, 1944, *51*, 220–229.

[11] Evans, W. A., and Leucutia, T. Deep roentgen-ray therapy of mammary carcinoma. III. Fifteen year results in a formerly published group and a statistical analysis of 1,200 cases treated between 1922 and 1937. AM. J. ROENTGENOL. & RAD. THERAPY, 1939, *42*, 866–882.

[12] Cori, C. F. Influence of ovariectomy on spontaneous occurrence of mammary carcinomas in mice. *J. Exper. Med.*, 1927, *45*, 983–991.

ments were divided into three groups. In one, bilateral oöphorectomy was performed at the age of fifteen to twenty-two days, immediately after weaning, that is before sexual maturity developed; in another, at the age of two to six months of life, that is after three to twenty estrus cycles had taken place, and in a third at the age of six to seven months, that is after forty estrus cycles occurred (the average mouse has seventy to eighty estrus cycles during life, each of from four to six days' duration.) It was found that in Group 1 not one single case of cancer developed; in Group 2, the incidence was reduced to 10 per cent and the cancer age was raised to from eighteen and one-half to twenty-one months, and in Group 3 there was no influence. From this the conclusion was drawn that "spontaneous mammary carcinoma of the mouse is due to a hereditary organ disposition, which remains latent in the absence of ovarian function but which becomes manifest when a certain amount of ovarian hormone, corresponding to 5 to 30 estrus cycles, has acted on the breast tissue."

Of further interest in this respect are the more recent experiments of Fekete, Woolley and Little.[13] These investigators observed that oöphorectomy at birth in a certain strain of mice is followed by a gradual recovery from the castrate state and the development of mammary cancer as if no castration had been done. The particular strain studied was the dba strain of the Jackson Laboratory which has about 50 per cent breast tumor incidence in virgin females. Oöphorectomy was performed on the first post partum day and the animals killed at different ages. Minute histologic studies revealed that the vagina, uterus and breast tissues showed a stage of development which they presumably can attain only under the influence of estrogenic hormones. In 37 of 75 animals examined, mammary tumors (3 adenomas and 34 carcinomas) developed between the ages of fourteen and twenty-eight months. The cortex of the adrenal gland consistently presented nodular hyperplasia, the morphologic appearance of which was similar to the lutein-like cells of the ovaries. It was suggested, therefore, that the adrenal cortex had taken over the function of the removed ovaries and since in no case was there evidence of regeneration of the ovarian tissue that the hypertrophic nodules of the adrenal cortex had become the new foci of estrogenic production. Other noteworthy points were that the marked nodular hyperplasia of the adrenal cortex appeared only in the later periods of the life of the animal and that the changes manifested themselves more rapidly after oöphorectomy at a more advanced age.

It is often difficult and hazardous to apply the results of animal experiments to the human. Fekete, Woolley and Little were very careful to point out that not even all strains of mice show the same behavior. Nevertheless, by carefully weighing the clinical and experimental evidence available up to the present, one may formulate the following conclusions concerning the value of castration in the treatment of mammary cancer.

(1) In the presence of osseous metastases, roentgen castration is beneficial in at least one-third of the cases. Therefore, its use in association with other established procedures, such as intravenous colloidal lead therapy, generalized irradiation of the affected areas, and so forth, is recommended. After a latent period of varying duration, however, recurrences or new metastases develop and the further progress of the cancer can be influenced but little. This may be explained on the assumption that through adjustment, other organs, as for example the adrenal cortex, have taken over the estrogen producing function or that the cancer, after breaking down all barriers of resistance, has simply gotten out of control. Perhaps additional information will be gained on this from a study of the remarkable response of osseous metastases which is now being observed with in-

[13] Fekete, Elizabeth, Woolley, George, and Little, C. C. Histological changes following ovariectomy in mice. *J. Exper. Med.*, 1941, *74*, 1–8.

creasing frequency in mammary cancer of the male following bilateral orchidectomy.

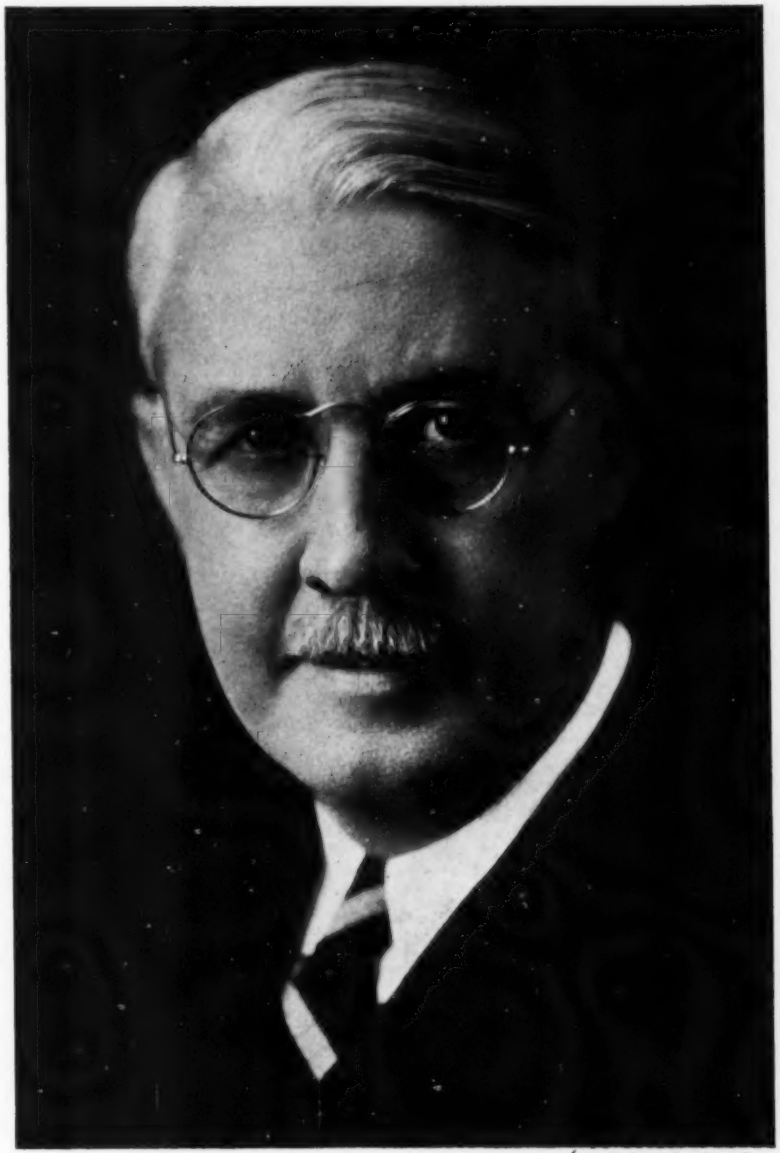
(2) In local recurrences and generalized visceral metastases, roentgen castration is of questionable value, although sporadic favorable results are described in the literature.

(3) In the operable group of mammary cancer, radical surgery associated with intensive local and regional irradiation seems to offer the best combination of treatment for the final success.

Surgical castration performed at the time of radical mastectomy has given, in the hands of Horsley,[8] very impressive results. It appears that the incidence of local recurrences and metastases is being reduced in the premenopausal age. However, a much larger series of cases is required before this conclusion can be made final. Also, there is not sufficient evidence as yet that surgical castration can replace local and regional irradiation as an adjunct to radical mastectomy. In the animal experiments, surgical castration to be of absolute value had to be performed before the onset of sexual maturity. If it was performed during a period corresponding to less than one-third of sexual life there still was a decrease in the incidence of mammary cancer, but after that there was no effect. At still later periods, the rather rapid readjustment in the balance of the endocrine system entered into play.

Routine roentgen castration in association with the above stated local and regional methods, to forestall or retard the appearance of distant metastases is for the time being considered inadvisable. Cori[12] in his experiments found that in almost 10 per cent of the oöphorectomized mice a remarkable regeneration of the ovarian tissue developed during later life. It is probable that following roentgen castration, as used currently, a similar regeneration occurs more quickly and in a more integral manner. For this reason a durable effect over a long period of time does not appear certain. It is conceivable, however, that in those instances in which osseous metastases are already in the process of formation, though undemonstrable by physical means, roentgen castration may have a beneficial effect in retarding their actual appearance.

T. LEUCUTIA



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JOHN THOMAS MURPHY
1885-1944

DR. JOHN T. MURPHY died on June 15 in his native city of Toledo, in St. Vincent's Hospital, where he had been Director of the Department of Radiology since 1919. His death was cardiovascular, and he had been incapacitated only a few months.

Dr. Murphy was born in Toledo, Ohio on August 15, 1885. He received the degree of M. D. from the Toledo Medical College in 1906. His active participation in radiology dates back to 1915 and was begun at Cook County Hospital in Chicago. He became a member of the American Roent-

gen Ray Society in 1918 and was its President in 1933; he served as its Secretary from 1928 to 1931. Those who attended recent meetings of the Society will look back with pleasure and profit on the courses he gave on the roentgen diagnosis and the clinical course of bone tumors. His exhibit in this field jointly with his associate Dr. Clarence E. Hufford won a silver plaque at the Fifth International Congress of Radiology in Chicago in 1937.

In addition to the American Roentgen Ray Society, Dr. Murphy numbered among his memberships the following: Academy of Medicine of Toledo and Lucas County, of which he was a past President; Detroit Roentgen Ray and Radium Society, Ohio State Roentgen Society, American Medical Association, serving as Secretary of its Section on Radiology for a number of years, a fellow of the American College of Radiology and its President in 1935, a fellow of the American College of Physicians, American Radium Society, Radiological Society of North America, Diplomate of the American Board of Radiology, Knights of Columbus, Fourth Degree. He was also an honorary member of the Toledo Notre Dame Society.

Dr. Murphy was married to Miss Leila Schuller in 1907; their daughter is now Mrs. Helen Carson of Toledo. Several years after the death of his first wife he was married to Miss Pauline Feil in 1916. Their children are Mrs. Jeanne Reynolds, Lieutenant John T. Murphy, and Patricia Murphy.

Dr. Murphy was a man of wide extracurricular interests. He was one of Toledo's pioneer airplane pilots. Long before pilots were licensed he flew his own plane and became a friend of many early fliers. He never lost his interest in aviation and he was one of the sponsors of the Civil Air Reserve in Toledo. He was a member of the track team in college and he always maintained his interest in athletics. He was a member of the American Amateur Athletic Association and President of the Toledo Figure Skating Club. In addition to being a fine skater, Dr. Murphy also excelled in golf. He was much interested in photography and was awarded many prizes for his unusual impressionistic photographic views.

Dr. Murphy was a friendly man and was a loyal friend. His influence and wise counsel were of much benefit in the many activities to which he gave so much of himself and his time. Whatever he undertook he entered into wholeheartedly. During all of his years as a member of the American Roentgen Ray Society he took an active part in its affairs and he had no small part in bringing radiology to the position of importance which it occupies in medicine today. He was a faithful attendant at the numerous medical meetings to which he belonged and he will be greatly missed both at the scientific discussions and the various social gatherings at which his presence was always welcome.

Ramsay Spillman

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual meeting: Joint Meeting of American Roentgen Ray Society and Radiological Society of North America, Palmer House, Chicago, Ill., Sept. 24–29, 1944.

American College of Radiology
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill.

Section on Radiology, American Medical Association
Secretary, Dr. U. V. Portmann, Cleveland Clinic, Cleveland, Ohio.

Arkansas Radiological Society
Secretary, Dr. J. S. Wilson, Mack Wilson Hospital, Monticello, Ark. Meets every three months and also at time and place of State Medical Association.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Joint Meeting of American Roentgen Ray Society and Radiological Society of North America, Palmer House, Chicago, Ill., Sept. 24–29, 1944.

Radiological Section, Baltimore Medical Society
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

Section on Radiology, California Medical Association
Secretary, Dr. Earl R. Miller, University of California Hospital, San Francisco, Calif.

Radiological Section, Connecticut Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

Section on Radiology, Illinois State Medical Society
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

Radiological Section, Los Angeles County Medical Association
Secretary, Dr. Roy W. Johnson, 1407 S. Hope St., Los Angeles, Calif. Meets on second Wednesday of each month at the County Society Building.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Brooklyn Roentgen Ray Society
Secretary, Dr. Leo Harrington, 880 Ocean Ave., Brooklyn, N.Y. Meets monthly on fourth Tuesday, October to April.

Buffalo Radiological Society
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

Chicago Roentgen Society
Secretary, Dr. F. H. Squire, 1754 W. Congress St., Chicago 12, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. Samuel Brown, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. D. D. Brannan, 11311 Shaker Blvd., Cleveland 4, Ohio. Meets at 6:30 P.M. at Allerton Hotel on fourth Monday each month, October to April, inclusive.

Dallas-Fort Worth Roentgen Study Club
Secretary, Dr. X. R. Hyde, Medical Arts Bldg., Fort Worth, Texas. Meetings held in Dallas on odd months and in Fort Worth on even months, on third Monday, at 7:30 P.M.

Denver Radiological Club
Secretary, Dr. Edward J. Meister, 366 Metropolitan Bldg., Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

Florida Radiological Society
Acting Secretary, Dr. Walter A. Weed, 204 Exchange Bldg., Orlando, Fla. Meetings in May and November.

Georgia Radiological Society
Secretary, Dr. James J. Clark, 478 Peachtree St., Atlanta, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

Radiological Society of Kansas City
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month at a place designated by the president.

Illinois Radiological Society
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

Indiana Roentgen Society
Secretary, Dr. H. C. Ochsner, Methodist Hospital, Indianapolis. Meeting held the second Sunday in May annually.

Kentucky Radiological Society
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in Apr.

Long Island Radiological Society
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

Louisiana Radiological Society
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

Michigan Association of Roentgenologists
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

Minnesota Radiological Society
Secretary, Dr. Annette T. Stenstrom, 1218 Medical Arts Bldg., Minneapolis, Minn. One meeting a year at time of Minnesota State Medical Association.

Nebraska Radiological Society
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. George Levene, Massachusetts Memorial Hospitals, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. H. R. Brindle, 501 Grand Ave., Asbury Pk. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

New York Roentgen Society
Secretary, Dr. Ramsay Spillman, 115 East 61st St., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:30 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

NORTH DAKOTA RADIOLOGICAL SOCIETY
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

OHIO RADIOLOGICAL SOCIETY
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati. Meets at time and place of annual meeting of Ohio State Medical Association.

PACIFIC ROENTGEN SOCIETY
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport.

PHILADELPHIA ROENTGEN RAY SOCIETY
Secretary, Dr. R. P. Barden, University Hospital, Meetings first Thursday of each month from October to May inclusive at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

PITTSBURGH ROENTGEN SOCIETY
Secretary, Dr. R. G. Alley, 4800 Friendship Ave. Meets second Wednesday each month, 4:30 P.M., October to June, Pittsburgh Academy of Medicine.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
Secretary, Dr. Murray P. George, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY
Secretary, Dr. A. M. Popma, 220 N. First St., Boise, Idaho.

ST. LOUIS SOCIETY OF RADIOLOGISTS
Secretary, Dr. E. W. Spinzig, 2646 Potomac, St. Louis, Mo. Meets fourth Wednesday of each month, except June, July, August, and September, at a place designated by the president.

SAN DIEGO ROENTGEN SOCIETY
Secretary, Dr. Henry L. Jaffe, Naval Hospital, Balboa Park, San Diego, Calif. Meets monthly on first Wednesday at dinner.

SAN FRANCISCO RADIOLOGICAL SOCIETY
Secretary, Dr. Martha Mottram, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., first six months of year at Toland Hall, University of California Hospital, second six months at Lane Hall, Stanford University Hospital.

SHREVEPORT RADIOLOGICAL CLUB
Secretary, Dr. R. W. Cooper, Charity Hospital, Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

SOUTH CAROLINA X-RAY SOCIETY
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

TENNESSEE RADIOLOGICAL SOCIETY
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

TEXAS RADIOLOGICAL SOCIETY
Secretary, Dr. Asa E. Seeds, Baylor Hospital, Dallas, Texas. Next annual meeting, Temple, Texas, January 17, 1945.

UNIVERSITY OF MICHIGAN DEPARTMENT OF ROENTGENOLOGY STAFF MEETING
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

UNIVERSITY OF WISCONSIN RADIOLOGICAL CONFERENCE
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

VIRGINIA RADIOLOGICAL SOCIETY
Secretary, Dr. E. L. Flanagan, 116 E. Franklin St., Richmond, Va. Meets annually in October.

WASHINGTON STATE RADIOLOGICAL SOCIETY
Secretary, Dr. Thomas Carlile, 1115 Terry St., Seattle. Meets fourth Monday each month, October through May, College Club, Seattle.

X-RAY STUDY CLUB OF SAN FRANCISCO
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly in evening on third Thursday.

CUBA

SOCIEDAD DE RADIOLOGÍA Y FISIOTERAPIA DE CUBA
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

BRITISH EMPIRE

BRITISH INSTITUTE OF RADIOLOGY INCORPORATED WITH THE RÖNTGEN SOCIETY
Medical Members' meeting held monthly on third Friday at 2:30 P.M. and Ordinary Meeting at same time on following Saturday, October to May, 32 Welbeck St., London, W.1.

SECTION OF RADIOLOGY OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)
Meets on the third Friday of each month at 4:45 P.M. at the Royal Society of Medicine 1, Wimpole St., London, W. 1.

FACULTY OF RADIOLOGISTS
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Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

LENINGRAD ROENTGEN RAY SOCIETY
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

MOSCOW ROENTGEN RAY SOCIETY
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

SCANDINAVIAN ROENTGEN SOCIETIES
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

TUBERCULOSIS CASE-FINDING PROGRAM

To the Editor:

The editorial in the June, 1944, issue of the American Journal of Roentgenology and Radium Therapy entitled "An evaluation of the roentgen methods used in mass chest surveys" is of particular interest to us because of an effective tuberculosis case-finding program in operation at the Home Office of the Metropolitan Life Insurance Company in New York City since 1927. Following its inception the incidence of pulmonary tuberculosis in our group of 13,000 to 14,000 Home Office employees was reduced quickly to a point where it was no longer a major problem and has been held there continuously. It is therefore a pleasure to affirm as facts many of the things which are assumed in the editorial to be true.

For many years prior to 1927 we were accustomed to send from the Home Office in New York City to cure at our Sanatorium at Mount McGregor an average of four cases of active pulmonary tuberculosis for each thousand Home Office employees. Most of them, 60 per cent to be exact, were in the advanced stages at the time of diagnosis. The fact that many cases came to light shortly after a physical examination reported as "normal" demonstrated clearly that such an examination was inadequate. It was with the hope that we could detect at least most of the advanced cases that we began in 1927 a routine fluoroscopic examination of the chest of all *applicants for employment* at the Home Office, and at each annual examination of all *Home Office employees*. The purpose of this fluoroscopic examination was not to diagnose tuberculosis, but rather to select the persons from an average healthy working group who needed further study, which included a 14 by 17 inch roentgenogram.

As soon as the program was fairly under way, our tuberculosis problem began to come under control. The incidence of tuberculosis among our Home Office employees which had been annually *four per thousand* prior to 1927 soon became *one per thousand*, and for many years has been *less than one per thousand* per year. Perhaps it is even more important that for the past ten years the *stage* of tuberculosis among new cases has been *73 per cent minimal* as contrasted to a former *60 per cent advanced*.

If this change had occurred simultaneously with a decreasing incidence of tuberculosis among applicants for employment, it could not properly be called a "control program." But the fact is that the incidence of chest lesions typical of pulmonary tuberculosis among applicants for employment has been relatively stable since 1927, has shown no real or consistent decrease, and does not differ materially from the incidence reported among inductees for the Armed Services. Incidentally, if a suspicious lesion is found in an applicant for employment, we make every effort to see that the case is followed to a conclusion, either by the family physician or at a clinic or hospital, and we have found practically no obstruction or lack of cooperation in our efforts.

It is interesting that the roentgenologic method rated in the editorial as least effective, namely, routine roentgenoscopy, supplemented with 14 by 17 inch roentgenogram when indicated, has brought about the result described above and in an economical manner. The most important decision to be made in any tuberculosis case-finding program, regardless of the method to be used, is *to begin!*

H. H. Fellows, M.D.
Assistant Medical Director

Metropolitan Life Insurance Company
New York, New York.

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

THE ARTHROPATHIES: A HANDBOOK OF ROENTGEN DIAGNOSIS. By Alfred A. de Lorimier, A.B., M.A., M.D., Colonel, Medical Corps, United States Army; Commandant, The Army School of Roentgenology, Memphis, Tenn.; Formerly Director, Department of Roentgenology, Army Medical School, Washington, D. C. Cloth. Price $5.50. Pp. 319, with 678 illustrations. Chicago: Year Book Publishers, Inc., 1943.

This volume is one of a series of handbooks on roentgenographic diagnosis. Webster's definition of a handbook is "a book or manual, usually of small size." The publisher has conformed to this definition by compiling a book of small size with small but legible print, which is a relief from the usual, more bulky volume on roentgenographic interpretation. The author has contributed to the handbook effect by very concise descriptions using the least number of words possible. Each disease is described by headings: synonyms, roentgenographic criteria, corroborative roentgenographic criteria, incidence, history, physical findings, clinical course and bibliography. The illustrations consisting of diagrams, roentgenograms and a few pathological specimens, number 678. These are compactly placed, two to four on a page, and are conveniently arranged in the text to illustrate the specific disease. The diseases are grouped according to their etiology. The result is a handy volume.

Colonel de Lorimier has had much experience in the teaching of roentgenology. The handbook is a compilation of lectures given him since 1938 at the Army Medical School and the Army School of Roentgenology. He states in the preface that the material is presented in the form followed by his teaching: "Instruction has been graphic, presenting first an orientation of the subject; then a catalogue by films or lantern slides of essential diagnostic criteria, and finally corroborative clinical and laboratory aspects." Under each heading the essentials for the diagnosis of the condition can be readily grasped. The illustrations have the salient roentgen changes marked with arrows. Occasionally the multiplicity of arrows tends to obscure the bone detail of the roentgenograms.

The book is certain to be useful and valuable to the student and roentgenologist for ready reference and essential diagnostic criteria. The bibliography is ample.

RALPH S. BROMER

THE MODERN MANAGEMENT OF COLITIS. By J. Arnold Bargen, M.D., M.S., F.A.C.P., Chief of the Section on Intestinal Diseases, Division of Medicine, Mayo Clinic; Associate Professor of Medicine, Mayo Foundation, Rochester, Minnesota; Secretary, American Gastroenterological Association; Vice Chairman, Section on Gastroenterology and Proctology, American Medical Association. Cloth. Price, $7.00. Pp. 322, with 148 illustrations. Springfield, Illinois: Charles C Thomas, 1943.

This monograph is devoted, as the author states in his preface, to a narration of his own observations and experiments based on the rich clinical material of the Mayo Clinic. He has made no attempt to review the voluminous literature on the subject but he has included 85 references in the bibliography. Theory and tradition about any intestinal ailment have been challenged by direct experimental attack and the results of such an attack have been set down in simple fashion. As a result, the book is pleasing in style, easily read and assimilated and well illustrated with reproductions of pathological specimens, roentgenograms, charts and tables. The part played by roentgenology in the diagnosis is well covered. It is now possible to distinguish accurately real inflammatory disease from functional colonic disorders. Bargen bases his classification of the types of ulcerative colitis on present day knowledge of their causation.

The list of chapters indicates the comprehensive scope of this monograph. They include: The Irritable Colon; Types of Ulcerative Colitis; Thrombo-Ulcerative Colitis: Streptococcal (Type 1); Regional (Segmental) Ulcerative Colitis (Type 2); Chronic Ulcerative Colitis (Type 3); Tuberculous Ulcerative Colitis

(Type 4); Amebic Ulcerative Colitis (Type 5); Colitis (Type 6): Its Relation to Food and Vitamin Deficiency; Ulcerative Colitis (Type 7): Due to the Virus of Venereal Lymphogranuloma; Allergic Colitis (Type 8); Chronic Ulcerative Colitis (Type 9): A Late Phase of Bacillary Dysentery; and a final chapter on Conditions to be Distinguished from Colitis.

This volume should be included among the reference books of the roentgenologist as an aid in diagnosis and more efficient collaboration with the gastroenterologist and the internist. The chapter on the irritable colon is to be especially commended.

Ralph S. Bromer

A Hundred Years of Medicine. By C. D. Haagensen and Wyndham E. B. Lloyd. Cloth. Price, $3.75. Pp. 444, with several illustrations. New York: Sheridan House, 1943.

This book deals in an effective and readable manner with the story of the development of our knowledge of various epoch making contributions to medicine and the men who made them. Although it is written in simple terms and is primarily for the layman, it is an excellent presentation of the facts concerning the most important advances in clinical medicine and the medical sciences. Physicians and medical students, as well as non-medical persons, could well read such a book with profit. Unquestionably it meets a definite need. It is not an all-inclusive encyclopedic volume, but it does appear to be an authoritative narration dealing with the important discoveries in medicine and surgery with which all educated persons should be familiar.

It is astonishing to the reviewer that intelligent lay persons, physicians, and medical students are often completely devoid of even the slightest curiosity concerning the historic development of our knowledge of medicine. Constantly, in the practice of medicine, important procedures are employed which have interesting stories behind them. A knowledge of these forms the basis for a scholarly grounding in the subject. But how many who may be reading this book review have any idea of when the important discovery of the x-ray by Wilhelm Konrad Roentgen occurred, or how he came upon this momentous discovery? Or, for example, when was the first transfusion with human blood accomplished? Or, to consider more recent events, when did Gerhard Domagk introduce the sulfonamide preparations, and what led to the discovery of the earliest forerunner of the drugs which so mightily combat certain infections? These and many other interesting questions are answered in this worthwhile publication. The sole approach to a complete understanding of any topic is the historical one. It is only by knowing and correlating every step of the development of our knowledge that we can have a true conception of any subject.

This book is not concerned entirely with the last hundred years of medicine which the title would have us believe, for the first division of fifty-five pages is devoted to the historic aspects of medicine up to one hundred years ago. Furthermore, in the description of the development of our knowledge, the authors go back very properly to the beginnings which in some instances were prior to 1844. The three other divisions of the book are devoted respectively to "Medical Science during the last 100 years, Surgery during the last 100 years, and the New Social Aspects of Medicine."

The historic story of medicine is attractively written, and hence may be read with interest and pleasure by the medical man and the layman. It is comprehensive in its scope for it appears to have included all of the more important advances in medicine and surgery. The descriptions seem to be accurate with minor exceptions. Some of the more modern developments are included such as the introduction of the sulfonamide drugs, but no reference is made to the remarkable effect of penicillin despite the fact that it was first described by Alexander Fleming in 1929, and its clinical worth was recognized in 1940. Some minor errors or omissions were noted by the reviewer in a few subjects in which he has special interest. For example, why was not the name of Richard Lower, Professor of Physiology at Oxford, mentioned as the one who first gave a blood transfusion from one dog to another? This event which occurred in Feburary, 1665, probably did more than anything else to stimulate interest in human blood transfusions which led ultimately to the perfection of the method.

Cyrus C. Sturgis

DEPARTMENT OF TECHNIQUE

Department Editor: ROBERT B. TAFT, M.D., B.S., M.A., 103 Rutledge Ave.
Charleston, S. C.

THE ADVANTAGE OF INCREASED FILTRATION

By WILLIAM S. ALTMAN, M.D.
QUINCY, MASSACHUSETTS

IT IS well known that, by the use of increased filtration, soft tissue detail and contrast are accentuated and there is a resultant added latitude. The addition of 1 to 3 millimeters (depending on the thickness of the part) will suffice. This additional filtration necessitates a 10 to 20 per cent increase in exposure.

FIG. 1

The procedure is of distinct value particularly in two types of examinations.

The first is in the visualization of the placenta in the lateral view of the abdomen. The use of 4 mm. of aluminum filtration brings out in better detail the placental tissue and helps to prevent the obliteration of the soft tissues of the abdominal wall (Fig. 1).

The second type of examination in which added filtration is of value is in the lateral view of the lumbosacral spine. Here again 4 mm. of aluminum is used as a filter. It will be noted that the vertebral bodies are clearly demonstrated, the laminae of the fifth lumbar vertebra are well outlined and the spinous processes are not obliterated (Fig. 2).

FIG. 2

32 Spear St.,
Quincy, Mass.

A PRINTING FRAME FOR MAKING COPIES OF ROENTGENOGRAMS

By WILLIAM S. ALTMAN, M.D.
QUINCY, MASSACHUSETTS

ON OLD or discarded cassette can be transformed into a printing frame by substituting glass for the bakelite (Fig. 1). An aluminum cassette may also be used if the aluminum front is cut out and replaced by glass.

The same frame can be used for smaller size films simply by making mats from the paper of a 14×17 inch film and cutting apertures to the size desired.

32 Spear St.,
Quincy, Mass.

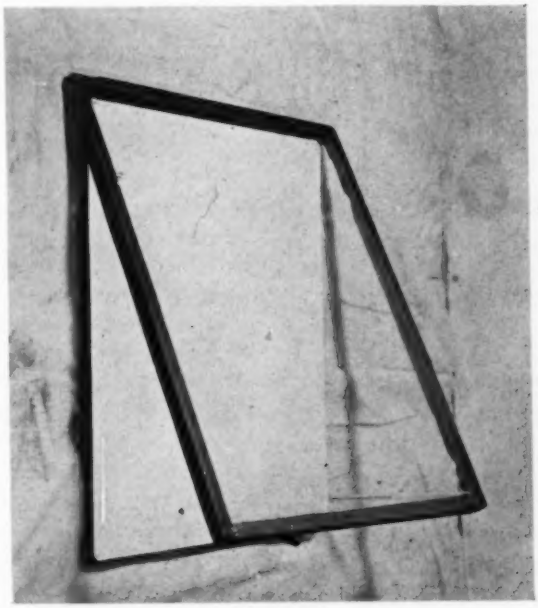

FIG. 1

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

SKELETAL SYSTEM

Palmquist, Walter N. Roentgen analysis of upper cervical spine injuries. *Radiology*, Jan., 1943, *40*, 49–55.

This paper presents a method of analysis of upper cervical roentgenograms with the aid of index lines. First there must be a clear accurate lateral film in making which the roentgen-ray beam should parallel, as nearly as possible, a line through the two ear openings. The analysis can be practiced directly on the film but it is better to make a tracing leaving the film unchanged.

The first guide line is a horizontal one passing medially through the body of the atlas. Three parallel lines are then drawn perpendicular to this one, passing respectively through the point where the first line intersects the anterior surface of the upper boundary of the odontoid, the point where it intersects the anterior surface of the atlas tubercle and the point where it intersects the mandible. A fifth line is drawn along the anterior edge of the body of the axis and a sixth through the lower anterior corner of the body of the axis and a sixth through the lower anterior corner of the body of the axis. Three additional guide lines may be helpful in anticipating possible later angulation dislocations. One is drawn as nearly as possible tangent to the anterior surface of any vertebra below the axis, one tangent to the upper surface of the fifth cervical vertebra and one tangent to the lower surface of the fourth cervical. Diagrams are given showing the application of the method.

These guide lines are of maximum significance only when the roentgenogram is made with the patient in the normal erect position. Their value is greatly impaired if the head is in hyperextension.—*Audrey G. Morgan.*

Englander, O. Non-traumatic occipito-atlanto-axial dislocation. *Brit. J. Radiol.*, Dec., 1942, *15*, 341–345.

In addition to fracture dislocation three types of non-traumatic occipito-atlanto-axial dislocation may occur: (1) forward dislocation of the atlas on the axis; (2) atlanto-axial rotation dislocation; (3) occipito-atlantoid dislocation. These dislocations may be caused by any inflammation in the upper part of the neck, such as acute tonsillitis, diseases such as syphilis or tuberculosis that destroy structures that enter into the atlantoid joints, unguarded sudden movements of the head or other trauma. Any of these dislocations may be manifested clinically by torticollis. In the roentgenogram the transverse process of the atlas can be palpated behind the mastoid in occipito-atlantoid dislocation. Normally it is palpated in front of the mastoid. The recognition of such a dislocation is important because it is more difficult to reduce than atlanto-axial dislocation. The only view in which occipito-atlantoid dislocation can be recognized in the submento-vertical or vertico-submental. One of the objects of this paper is to show the importance of this view. A case of occipito-atlanto-axial dislocation is described in a girl seven years of age. It followed acute tonsillitis and bilateral suppurative submaxillary lymphadenitis. In addition to this view the lateral and anteroposterior views are of value. A roentgenogram, tomogram and tracing of a tomogram of the case are given. Roentgenograms of the normal upper cervical spine are also given for comparison.—*Audrey G. Morgan.*

Gray, E. D. Calcification and ossification of spinal tumours. *Brit. J. Radiol.*, Dec., 1942, *15*, 365–369.

Spinal tumors are sometimes directly visible on plain roentgenograms because there are areas of calcification or ossification within them. This occurs in perhaps not more than 10 per cent of cases of spinal tumor and examination is rarely made for them because of the difficulty of roentgenography of the spinal canal. Tomography has proved of considerable value in this field and will doubtless become increasingly valuable in the future.

Three such cases have been seen in the last three years at the Manchester Royal Infirmary. They are described and illustrated with roent-

genograms. Two of them were meningiomas, one of the psammomatous and the other of the osteoblastic type. The other was an intramedullary tumor, probably a hemangioblastoma. All of these tumors were in the dorsal region, as are the majority of these calcified or ossified tumors. The great majority of them are also meningiomas, particularly of the psammomatous type. The image seen in the roentgenogram is that of an olive-shaped opacity in the spinal canal. Generally there are no associated indirect signs, such as thinning of the pedicles or enlargement of the foramina.—*Audrey G. Morgan.*

PEIRCE, CARLETON B., and EAGLESHAM, DOUGLAS C. Traumatic lipohemarthrosis of the knee. *Radiology*, Dec., 1942, *39*, 655–662.

The authors describe 7 cases of fracture of the tibia in one of which the fracture was bilateral and in which roentgen examination showed layering of the joint fluid, indicating the presence of blood and fat. They call attention to the presence of a subpatellar deposit of fat and similar smaller deposits around the base of the cruciate ligaments. None of these lies in the synovial space and severe injury is required to produce extravasation of fat from these deposits into the joint space. On the other hand, hemorrhagic effusion may occur without severe injury.

They suggest examination in the supine position with a horizontal lateral projection as a method which permits of the demonstration of this layering and spares the patient movement as far as possible. In one of the cases aspiration was done and the presence of fat in the fluid demonstrated. They suggest the name of traumatic lipo-hemarthrosis for this condition.

In the discussion Dr. Harbin said that while he had aspirated blood from many injured knees he had never found fat present in the fluid. He regretted that the authors of this article had not performed aspiration and demonstrated the presence of fat in more of their cases. The layering might be due to clotting of the blood with separation of the blood into corpuscles and serum, the layers being of different densities.—*Audrey G. Morgan.*

STEINER, HOWARD A. Roentgenological manifestations and clinical symptoms of rib abnormalities. *Radiology*, Feb., 1943, *40*, 175–178.

Among 38,105 roentgenograms showing the ribs made at the Department of Radiology of the University of Colorado Medical School 59 showed anomalies of the ribs (0.15 per cent). There were 19 cases of cervical ribs and 17 of lumbar ribs, making up more than half of the total number. The others were bipartition or forking of the anterior ends of the ribs, synostosis or bony union of adjoining ribs, tile-roof ribs, or imbrication, rudimentary ribs and a few other unclassified deformities. The patients ranged from five to seventy-eight years of age; 30 were males and 29 females.

In 10 of the cases of cervical rib and 12 of the other cases there was a very definite correlation between the anomaly of the ribs and pain. In one of the cases of bipartition, 2 of synostosis and 3 of the 4 of tile-roof ribs there was tuberculosis or pneumonia, evidently due to limitation of space in the thorax by the anomaly. In 26 of the cases no relationship could be found between the rib anomalies and any clinical symptoms. In 17 of these cases the abnormality was of such a nature that no anatomical or physiological disturbance was to be expected.—*Audrey G. Morgan.*

TENNENT, WILLIAM. Bi-lateral fractures of the clavicles. *Brit. J. Radiol.*, July, 1942, *15*, 211.

Fracture of one clavicle is one of the commonest accidents seen in roentgenography but fracture of both clavicles is very rare. A case is described in a man of forty-nine who was struck on one shoulder by a truck and hurled violently against an approaching streetcar, striking on the other shoulder. The roentgenogram showing fracture of both clavicles is shown. In these cases the lungs are almost always affected and breathing is very difficult when the patient is lying down. In this case the patient had to lie on a stretcher for an hour before admission to the hospital and he was definitely cyanotic when admitted.—*Audrey G. Morgan.*

BLOOD AND LYMPH SYSTEM

BRAKELEY, ELIZABETH. Leukemia resembling chloroma. *Am. J. Dis. Child.*, Oct., 1942, *64*, 689–696.

The author reports a case of lymphatic leukemia with the clinical appearance of chloroma in a boy, aged two and a half. The patient had an enlarged head, with wide separation of the sutures, pronounced exophthalmos and enlarged lymph nodes, especially of the neck and

mediastinum, but no metastases to bone. The predominating white cell was a lymphoblast, and no myelocytes or myeloblasts were seen.

The roentgenogram of the skull showed widening of the sutures and the absence of metastases. The roentgenographic examination of the chest before roentgen therapy showed pronounced widening of the mediastinal shadow and after therapy showed marked reduction in the width of the mediastinum.—*R. S. Bromer.*

Hodes, Philip J., Forrester, J. S., and Lockwood, J. S. [Lymphosarcoma]. *Radiology*, Feb., 1943, *40*, 188–190.

This clinico-pathological conference was based on the case of a Jewish woman, aged forty-three, admitted to hospital in August, 1941, complaining of pain in the right cheek and swelling of the right submaxillary and cervical lymph nodes which had existed for eight months, during which time anorexia and vomiting had developed and she had lost 30 pounds in weight. Examination showed soft masses in the right cheek, a hard irregular mass in the right breast, one in the axilla and several smaller lumps in the left breast. Masses in the lower abdomen were thought to be attached to the uterus. Laboratory studies, including blood count, were normal. Roentgenograms of the sinuses showed chronic disease of both antra with polypoid changes on the right side. After four weeks' treatment she improved somewhat and was discharged but returned in November, 1941, with a great increase in the size of the abdominal mass, dyspnea and cough. Bilateral salpingo-oophorectomy was performed in December. The patient failed rapidly and died in January, a year after the beginning of symptoms.

In the discussion Dr. Lockwood said this was an unusual case. The patient had a chronic wasting disease with lumps in each breast which suggested carcinoma with wide-spread metastases. But because of the diffuse nature of the disease, its spotty manifestations in widely separated lymph nodes and the soft tissue masses in the cheeks and breasts he concluded it was some type of lymphoblastoma, Hodgkin's disease, sarcoma or leukemia.

The patient was given small doses of roentgen therapy to right cheek, breasts and axilla from October 2 to December 27. The total amount was small, the maximum being 650 r total to the right cheek. This small dosage was given because it was believed that the tumor was radiosensitive but it is now believed that more vigorous treatment would have been better.

Sections from the first biopsy of an inguinal lymph node suggested leukemia or Hodgkin's disease. On autopsy practically every organ in the body was invaded by tumor and all the lymph nodes were greatly enlarged. Histopathologic examination suggested lymphosarcoma rather than the ordinary type of Hodgkin's disease.

Clinical diagnosis: carcinoma of the breast; uterine fibroid. Dr. Lockwood's diagnosis: lymphoblastoma. Diagnosis from biopsy: probable Hodgkin's disease. Final pathological diagnosis: lymphosarcoma.—*Audrey G. Morgan.*

GENERAL

Thornhill, Patti S., and Thornhill, Edwin H. Boeck's sarcoid with nodular iritis in a child. *Am. J. Dis. Child.*, Aug., 1942, *64*, 262–269.

Boeck's sarcoid is a chronic, relatively benign disorder of unknown cause with particular predilection for the lymph nodes, lungs, skin and bones; less frequently there is involvement of the liver, spleen, kidneys, eyes, brain or meninges. A case of ocular involvement is reported in a Negro girl aged nine. The differential diagnosis was: (1) tuberculous iritis, (2) syphilitic iritis and (3) Boeck's sarcoid. By means of physical examination, roentgenograms, intradermal tuberculin and Wassermann tests, repeated examinations of the sputum, inoculations of guinea pigs and histopathological studies of a lymph node, the diagnosis of Boeck's sarcoid was established. Roentgen examination showed bilateral symmetric enlargement of the hilar lymph nodes and a diffuse infiltration of the lungs.

In the authors' survey of the literature it was found that the eye was not a favorite seat of the disease as has been claimed by some. They report the case because of the rarity of ocular lesions in children.—*R. S. Bromer.*

Smyth, F. S., Soley, Mayo H., Lisser, Hans, Goldman, Leon, Miller, E. R., and Lindsay, Stuart. Medical staff conference on parathyroid gland disease, University of California Medical School Hospital, San Francisco. *Radiology*, Dec., 1942, *39*, 715–730.

The case on which this conference was based

was that of a woman of forty-nine who had hypoparathyroid tetany following thyroidectomy. She was placed on a high calcium, low phosphorus diet and treated with dihydrotachysterol, resulting in a decrease of blood phosphorus. On presentation she still showed evidence of old thyroidectomy. The Chvostek and Trousseau reactions were negative, skin dry, eyes somewhat puffy, nails brittle, no visible cataracts and no carpopedal spasm.

Parathyroid disease in children was discussed. Many conditions with demineralization of the bones in children are due to hyperparathyroidism. In such cases it is necessary to preserve a proper calcium-phosphorus balance in the blood serum, and not only the intake of these minerals but also their digestion must be watched. The Aub method of detecting excretion of calcium and phosphorus in urine and stools is valuable in following up these cases. Illustrative cases are described. Secondary parathyroidism associated with profound renal disturbances is more frequent in children than in adults.

In hypoparathyroidism the typical clinical sign is tetany; in hyperparathyroidism one of the typical clinical signs is weakness and hypotonia of the muscles. Among the laboratory findings in hyperparathyroidism are generalized osteoporosis, cysts, tumors and fractures of the bone, blood calcium is increased and blood phosphorus decreased while the opposite condition prevails in hypoparathyroidism.

The treatment of hyperparathyroidism is chiefly surgical to remove excessive parathyroid tissue, while hypoparathyroidism is generally caused by the inadvertent removal of too much parathyroid tissue in thyroidectomy. Treatment of hypoparathyroidism is by intravenous administration of calcium gluconate, oral administration of calcium, giving of thyroid substance, and the administration of vitamin D and dihydrotachysterol. This drug is a photochemical derivative of ergosterol and is commonly called A.T. 10 because it is anti-tetanic preparation No. 10. Its dosage should be controlled by the Sulkowitch test.

Roentgen examination is of little value in hypothyroidism. In hyperthyroidism it shows the typical bone changes, which must be differentiated from those of bone cysts, disseminated osteitis fibrosa, giant cell tumors and enchondroma. Typical roentgenograms are given.

In primary hyperparathyroidism the lesion that generally causes the high blood calcium and osteoporosis is a solitary chief cell adenoma of one gland. In secondary hyperparathyroidism with severe renal disease (renal rickets) there is hyperplasia of all the glands. Carcinoma of the parathyroid glands is rare and does not generally cause hyperparathyroidism.

In the discussion attention was called to the danger of giving excessive amounts of vitamin D in hyperparathyroidism and rickets and to the importance of using the Sulkowitch test in giving A.T. 10 because of its cumulative action. —*Audrey G. Morgan.*

JACKMAN, JAMES. Roentgen features of scleroderma and acrosclerosis. *Radiology*, Feb., 1943, *40*, 163–168.

Four cases of scleroderma and acrosclerosis are reviewed and illustrated with roentgenograms and the literature reviewed. The characteristic roentgen findings of these diseases are calcinosis, changes in the bones and in some cases pulmonary fibrosis and stenosis of the esophagus. Calcinosis is the most striking feature. Calcium is deposited in various parts of the body, particularly parts subjected to pressure. In acrosclerosis the hard plaques can often be felt and ulceration of the distal phalanges generally occurs. Slow progressive absorption of the distal phalanges of the fingers is quite common. An increase in the calcium content of the distal phalanges may also occur. Synostoses between the distal and middle phalanges may occur. Subluxations have been reported.

The calcinosis may be due to the fact that calcium remains in solution in live tissue which has an acid reaction but when tissue is dead and the reaction becomes alkaline calcium is deposited.—*Audrey G. Morgan.*

ROENTGEN AND RADIUM THERAPY

PATERSON, RALSTON. Radiotherapy and the cancer act. *Brit. J. Radiol.*, Oct., 1942, *15*, 297–301.

The application of the Cancer Act of 1939 after the war promises to have a profound effect on radiotherapy. It requires the creation of cancer diagnostic services and the provision of adequate treatment by both surgery and radiotherapy. A table of cancer incidence is given showing the enormity of the task to be faced. A large part of the difficulty in the effec-

tive treatment of cancer has lain in the failure to diagnose the disease early either from neglect of the symptoms on the part of the patient or failure of the general practitioner to recognize them for what they are. This should be corrected by having diagnostic clinics in charge of specialists trained in the diagnosis of cancer in every community so that no patient would have to travel far for examination.

In contrast with this decentralization in diagnosis there should be large cancer units for treatment, each one serving a population of not less than a million people, yielding about 900 cancer cases. In thinly populated sections it might be possible to establish a unit for each half million people, though efficiency in treatment would probably increase up to two million. The radiotherapists who treat cancer should be full-time specialists. The deep therapy equipment should be concentrated in the major treatment centers. The surgical treatment of cancer should also be centralized in these large cancer units.

It is much better psychologically for hopeless cancer patients to be treated at home. Some scheme should be devised by which adequate home nursing could be provided. This should be a much more complete nursing service than is provided by the daily visit of a district nurse.—*Audrey G. Morgan.*

Ellinger, Friedrich. The problem of recovery from radiation effects. *Radiology*, Jan., 1943, *40*, 62–71.

According to the point of view of photochemistry, irradiation produces toxic substances in the body from the disintegration of cells. Recovery takes place either by these substances being recombined into their original forms by a reversible chemical action or by their being removed by diffusion. The circulation plays an important part in the latter process.

Clinical recovery means the restoration of organ structure and function. This may result from the recovery of their normal function by cells that have been injured, in which case it is true recovery. Or it may result from proliferation of cells that have escaped injury which take the place of the injured cells. This is called pseudo-recovery. Experimental work on various kinds of tissue is described which seems to show that the greater part of the recovery after irradiation is pseudo-recovery. The tissues most capable of recovery are those with a high power of regeneration, such as skin, testicles and hair follicles. Recovery depends on the regenerative power of the irradiated tissue, the dose of irradiation, the time in which the dose is given and the blood supply of the tissue.

The recovery of tumors from the effects of irradiation is of great clinical importance. Probably pseudo-recovery takes place in tumor tissue just as it does in normal tissue, as tumor tissue has very great regenerative power. The fact that some tumors become radioresistant after a certain amount of irradiation seems to confirm this theory.—*Audrey G. Morgan.*

Finzi, N. S. Management of x-ray reactions. *Brit. J. Radiol.*, July, 1942, *15*, 192–193.

In a discussion before the Faculty of Radiologists, Finzi stated that there is some difference in the local reactions to 200 kv. and 1,000 kv. roentgen rays. With the shorter wave lengths the reactions were sharper but subsided more quickly and kept drier. For the same biological effect more roentgens of the higher voltage are required in the proportion of 3 to 2.

Skin erythema was less severe when the skin was kept dry and no ointments used. During treatment starch powder gave relief. After treatment a mixture of either calamine or zinc and starch powder with an equal quantity of bismuth carbonate was used. For vesication, linamentum calaminae with 2 grams of phenol per ounce was effective. Acute ulceration was relieved by an ointment of 5 per cent benzocaine or cycloform in vaseline. For chronic ulceration sulfonamides, sulphathiazole or flavine in paraffin or castor oil were satisfactory. Ultraviolet treatment was not found satisfactory.

Mucous membrane reactions were earlier than skin reactions and passed off sooner. Heavy irradiation devitalized bone so that spontaneous fractures failed to heal. Diarrhea was caused by the action of the rays on the intestines. Ten gr. salol three times a day was good for this condition. The lungs are very radiosensitive and lung injuries difficult to treat. Operation through tissue devitalized by operation is dangerous.

For general reactions such a nausea and vomiting adrenalin in 10 minim doses every hour until relieved was very effective. Vitamin C in 3,000 gm. doses has also been recommended. Liver extract was not found to be of any value. Large doses of iron were useful.—*Audrey G. Morgan.*

SMITHERS, D. W. Control and treatment of radiation reactions. *Brit. J. Radiol.*, Aug., 1942, *15*, 233–236.

The general reactions to radiation include the generalized skin reactions, the effects on the blood count and the symptoms known as roentgen sickness, such as anorexia, nausea and vomiting. A study of roentgen sickness has shown that it is most apt to occur in nervous, high-strung patients in poor general health who are given frequent large integral doses to a large radiosensitive tumor. Charts are given showing the integral doses administered in certain types of tumor. Good results have been obtained in roentgen sickness by giving injections of vitamin B and histaminase.

The blood count seems to be favorably affected by the administration of vitamin C and recently sodium bicarbonate has been given in conjunction with the vitamin C with good results. It promotes the storage of the vitamin in the body. Vitamin C often brings about an increase in the total cell count and the lymphocyte count even while treatment is being continued with the same integral dose each day.—*Audrey G. Morgan.*

MISCELLANEOUS

WEATHERALL, M. The pharmacological actions of some contrast media and a comparison of their merits. *Brit. J. Radiol.*, May, 1942, *15*, 129–137.

A study was made of the pharmacological actions of 7 contrast media containing iodine. Four of them were found unsuitable for clinical use. One of them that showed promise in experimental work was found to be poorly tolerated by human subjects. This left three worthy of use for pyelography and a clinical testing of their value in angiography, particularly cerebral angiography for which no satisfactory medium has as yet been found. These three are diodone, which is sold under the trade names of perabrodil and diodrast, iodoxyl, the pharmacological name of uroselectan B, and sodium o-iodohippurate, which is sold as hippuran.

Their effects on heart, blood vessels and blood pressure were tested and tracings showing the results are given. It was found that diodone is the most suitable medium for use in pyelography, cardiography and angiography. It was given by intracarotid injection to cats to test its suitability for cerebral angiography and is believed worthy of clinical testing for this purpose.—*Audrey G. Morgan.*

MEYER, H. The quantitative determination of radium by a photographic method. *Brit. J. Radiol.*, March, 1942, *15*, 85–91.

A method of photographic quantitative determination of radium with a very simple apparatus is described and a diagram of the apparatus given. It is simple and the main sources of error in other photographic methods, such as variations of the emulsions of different films and uneven blackening are overcome by it. It consists of two identical lead blocks 20 cm. high, 15 cm. long and 10 cm. wide standing 25 mm. apart on a wooden support. The radium source is placed centrally between the two blocks and the radiation filtered through a lead filter. The films should be processed in total darkness as the blackening produced by a darkroom safelight may introduce errors up to 20 per cent. Development should follow exposure as soon as possible as a delay of twenty-four hours or more may cause an error. Densities should preferably be measured by a microphotometer but if this is not available a Weston photronic foot-candle meter, model 614, or a similar instrument may be used.

This method is particularly adapted for measuring weak sources of radiation. In order to shorten the exposure time, which is long for such preparations, the distance between the radium source and the film may be decreased.

The photographic method of course cannot replace air ionization methods for precision measurements in large institutions but is especially adapted for use in chemical laboratories where considerable amounts of open radium salts and solutions are used, and isolated measuring rooms and the services of skilled physicists are not available.—*Audrey G. Morgan.*